MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *February* 14, 1868. No. 4.

Rev. CHARLES PRITCHARD, M.A. F.R.S., President, in the Chair.

Charles Henry Brooks, Esq., Merton, Surrey;
George Stickland Criswick, Esq., Royal Observatory, Greenwich;
Lieut. Seymour Morse Davies, R.A., Upton Park, Slough; and
John Parnell, Esq., Hadham House, Upper Clapton,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Forty-eighth General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1866	173	278	14	4	469	47	516
Since elected ...	8	21	...	...	...	...	...
Deceased	−3	−6	−1	...	...	−1	...
Expelled	...	−1	...	...	...	...	...
Resigned	...	−5	...	...	...	...	...
Removals	+1	−1	...	...	...	...	...
Dec. 31, 1867 ...	179	286	13	4	482	46	528

Mr. Whitbread's Account as Treasurer of the Royal Astronomical Society, from January 1 to December 31, 1867:—

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance of last year's account	95	14	7			
Plus: Pearson's cheque lost and unpaid, for which a second cheque was given	2	10	0			
				98	4	7
By Dividend on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents ...	73	15	0			
By ditto on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents ...	73	15	0			
				230	2	0
On account of arrears of contributions ...	199	10	0			
176 annual contributions	368	11	0			
28 admission-fees	58	16	0			
19 first years' contributions	33	12	0			
	660	9	0			
10 compositions	207	18	0			
				868	7	0
Sale of publications				80	12	6
				£1277	6	1

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries:—						
Editor of Publications	60	0	0			
Assistant Secretary	115	0	0			
Commission on Collecting	37	1	0			
				212	1	0
Taxes:—						
Land and Assessed	6	11	0			
Income	1	13	4			
Poor Rate	11	13	4			
Other Parish Rates	3	19	2			
				23	16	10
Repairs:—						
Boobbyer, ironmonger	3	2	0			
				3	2	0
Bills:—						
Strangeways and Walden, printers ...	601	17	8			
Rumfitt, bookbinder	12	5	1			
Basire, engraver	52	3	6			
Pearson, wood-engraver	8	2	0			
Joyce	1	5	0			
J. Beck	2	0	0			
Johnson and Co., engravers	13	13	0			
Wyon, medals	57	15	0			
Annual Dinner (deficiency)	18	12	0			
Insurance	10	0	6			
				777	13	9
Miscellaneous items:—						
House expenses	22	6	3			
Postages	42	12	6			
Books and parcels	3	14	5			
Expenses of evening meetings	13	13	0			
Waiters attending meetings	3	17	0			
Coals and wood	12	0	0			
Gas	5	4	10			
Repairs	5	8	0			
Sundries	16	7	2			
				125	3	2
Turnor Fund	3	12	3			
Mrs. Jackson's annuity, 1 year	8	13	4			
Mrs. Maynard. Gift	5	0	0			
				17	5	7
Cheque-book				0	5	0
				1159	7	4
Balance at Banker's				117	18	9
				£1277	6	1

Examined and found correct, 1868, February 3,
EDWIN DUNKIN,
Examined and found correct, Feb. 10th, 1868,
JOHN BROWNING, } *Auditors.*

Assets and Present Property of the Society, January 1, 1868:—

	£	s.	d.	£	s.	d.
Balance at Banker's	...		...	117	18	9
2 Contributions of 6 years' standing ...	25	4	0			
12 ,, 4 ,, ...	100	16	0			
19 ,, 3 ,, ...	119	14	0			
25 ,, 2 ,, ...	105	0	0			
41 ,, 1 ,, ...	86	2	0			
2 admission-fees, and first contributions ...	6	6	0			
				443	2	0
Due for Publications	...		...	2	14	6
£5000 New 3 Per Cents (including Mrs. Jackson's Gift, £300).						
£2800 Consols, including the Lee Fund (£100) and Turnor Fund (£500).						
Unsold Publications of the Society.						
Various astronomical instruments, books, prints, &c.						
Balance of Turnor Fund (included in Treasurer's Account)				112	11	6

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	14	XI.	191	XXIV.	192
I. Part 2	54	XII.	198	XXV.	202
II. Part 1	72	XIII.	210	XXVI.	210
II. Part 2	36	XIV.	400	XXVII.	449
III. Part 1	89	XV.	179	XXVIII.	425
III. Part 2	108	XVI.	204	XXIX.	446
IV. Part 1	108	XVII.	201	XXX.	200
IV. Part 2	120	XVIII.	183	XXXI.	184
V.	134	XIX.	195	XXXII.	212
VI.	155	XX.	188	XXXIII.	224
VII.	179	XXI. Part 1	316	XXXIV.	230
VIII.	165	XXI. Part 2	100	XXXV.	415
IX.	168	XXI. (together).	97	XXXVI. (with M. N.)	483
X.	181	XXII.	187	XXXVI. (without)	120
		XXIII.	186		

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatorial,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1,
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle.

The *Sheepshanks*' collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatorial stand and clock movement.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and $2\frac{1}{4}$-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.

43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.

The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument, No. 1, to Mr. Lassell.
Ditto ditto No. 2, to Mr. De La Rue.
Ditto ditto No. 3, to Major Tennant.
Ditto ditto No. 4, to Rev. C. Lowndes.
Ditto ditto No. 5, to Mr. Birt.
Ditto ditto No. 6, to Rev. J. Cape.
Ditto ditto No. 8, to Rev. C. Pritchard.
Ditto ditto No. 9, to the Director of the Sydney Observatory.
Ditto ditto No. 41, to Rev. C. Pritchard.
Ditto ditto No. 43, to Mr. Huggins.
The 6-inch circular protractor, to Mr. Birt.

The Gold Medal.

The Council have awarded the Gold Medal to M. Leverrier for his Solar and Planetary Tables. The President will, in the usual way, explain the grounds of this award.

Printed Transactions of the Society.

Two volumes of *Memoirs* have been published since the last Report. Volume XXXV. contains four papers. Two of them are by Sir Thomas Maclear of observations made at the Cape of Good Hope. The former of these consists of the "Mean North Polar Distances of *Rigel*, *α Orionis*, *Sirius*, and *α Hydræ*, for January 1 of each Year, derived from Observations with the Transit Circle, in the Years 1856–63." The second paper contains "Geocentric Right Ascensions and North Polar Distances of Encke's Comet." The third paper is a valuable "Synopsis of all Sir William Herschel's Micrometrical Measurements and Estimated Positions and Distances of the Double Stars described by him, together with a Catalogue of those Stars, in order of Right Ascension, for the Epoch 1880·0," by Sir John F. W. Herschel.

This volume also contains, from the pen of the Rev. W. R. Dawes, a very important and extensive "Catalogue of Micrometrical Measurements of Double Stars, comprising all the measures obtained by him between the close of his Second Series (published in the *R. A. S. Memoirs*, vol. xix.) and the present time."

Volume XXXVI. consists of the observations made by Mr. Lassell during his last sojourn at Malta. These observations are arranged in three papers: I. Observations of Planets and Nebulæ; II. Miscellaneous Observations; III. A Catalogue of New Nebulæ discovered at Malta. Mr. Lassell's observations are illustrated by eleven plates.

Obituary.

The Society has to regret the loss by death of the following Fellows and Associate:—

Fellows.—The Earl of Rosse.
Lord Wrottesley.
Sir James South.
Rev. W. R. Almond.
Rev. Dr. Nicholson.
Mr. William Brooke.
Mr. J. J. Downes.
Mr. Charles Howell.
Rev. Miles Bland.
Mr. Thomas Heelis.

Associate.—Dr. Bache.

A notice of the life and labours of Lord Rosse will appear, it is expected, in the *Monthly Notices* for April.

John, second Baron Wrottesley, was the eldest son of Sir John Wrottesley, Bart., of Wrottesley, near Wolverhampton, in Staffordshire, who was raised to the Peerage as Baron Wrottesley. He was born on the 5th of August, 1798, and graduated first class in Mathematics at Oxford in 1817, being a Member of Corpus Christi College. He succeeded his father in the Barony on the 16th of March, 1841.

Taking much interest in Practical Astronomy, he became, as Mr. John Wrottesley, an original Member of this Society, and contributed various observations, chiefly of the stars, to its *Monthly Notices* and *Memoirs*. In the year 1829 he commenced the erection of an Observatory at Blackheath, where he began to observe, assisted by Mr. John Hartnup (afterwards Assistant-Secretary to the Royal Astronomical Society and now Astronomer of the Observatory at Liverpool), in the spring of 1831; having a transit-instrument by Thomas Jones, of 62 inches focal length, and clear aperture $3\frac{3}{4}$ inches, and a clock by Hardy. Being provided with such means of making astronomical observations, he determined to fix upon some definite object, and steadily pursue that alone. He, accordingly, selected 1318 stars from the Astronomical Society's Catalogue of 2881, being the stars of the sixth, and from that to the seventh magnitude inclusive, resolving to determine their right ascensions, observing, if possible, each star at least ten times. Having ascertained everything necessary to be known respecting the qualities of the instruments about to be employed, Mr. Wrottesley began the observation of his Catalogue on the 9th of May, 1831, and on the 1st of July, 1835, the task was brought to a conclusion. The Catalogue so produced embodies the results of 12,007 observations, exclusive of those of the stars required for comparison. It was read before this So-

ciety on the 11th November, 1836, and published in the Society's *Memoirs*, vol. x.

The Council awarded the Gold Medal to the author, to whom it was presented by the President, the late Mr. F. Baily, at the Annual General Meeting of February 8, 1839, after he had delivered an appropriate address, in which he informed the Society that when the requisite comparisons had been made with the positions of the same stars obtained at the public observatories, —and every star in Mr. Wrottesley's Catalogue, he also stated, had undergone that investigation, — the result had shown that his Catalogue was of first-rate importance, and entitled to implicit confidence. A Supplemental Catalogue of the right ascensions of fifty-five Stars, also observed at Blackheath, appears in the 12th volume of the *Memoirs*. At the Annual Meeting of 1841, Mr. Wrottesley was elected President, in which capacity, after his accession to the title of Lord Wrottesley, he delivered two addresses, on the presentation of the Gold Medal to Professor Hansen, of Gotha, in 1842, for his researches in physical astronomy, and to Mr. F. Baily, in the following year, for the experiments in which he virtually repeated the Cavendish experiments to determine the mean density of the Earth. On April 29th, 1841, he had been elected a Fellow of the Royal Society.

In the beginning of the year 1842, Lord Wrottesley resolved on erecting an observatory near his residence, Wrottesley Hall; and on the 29th of March in that year, the first stone was laid by his youngest son, the late Cameron Wrottesley, Lieut. R.A., who had distinguished himself by his mathematical attainments, and had begun his career as an astronomical observer, which was unhappily terminated by his being killed at the siege of Bomarsund in 1854. The observatory was designed to contain the transit-instrument, with which the stars of the Blackheath Catalogue had been observed, and an equatorial telescope, with rooms for the observer. The observatory is described, and a plan of it given, in the introduction to the Catalogue of Stars in that of the British Association, of which an account is subjoined. The telescope is an achromatic, of 10 feet 9 inches focal length, with an object-glass of $7\frac{3}{4}$ inches clear aperture, of which the flint-glass is by Guinand and the crown by the elder George Dollond, who gave the curves to the glasses and completed the instrument. The years which immediately succeeded the foundation of the Wrottesley Observatory were employed in obtaining its position (N. Lat. 52° 37′ 23″, Longitude West of Greenwich in time $8^m\ 53^{s}\cdot57$), and in observations with the equatorial, which Lord Wrottesley communicated to the Royal Society, and which have been published in the *Philosophical Transactions* for 1851. This communication is entitled, "On the Results of Periodical Observations of the Positions and Distances of Nineteen of the Stars in Sir John Herschel's Lists of the Stars favourably situated for the Investigation of Parallax, contained in Part iii. of the *Phil. Trans.* for 1826, and in Part i. of 1827." The inquiry to

which it relates constitutes another example of the mode of doing good service to Astronomy which Lord Wrottesley early prescribed to himself, and which he has steadily pursued.

Sir J. F. W. Herschel had shown in the papers referred to, and again in his Treatise on Astronomy, that if a star which is optically, though not physically, double (that is, one the component single stars of which appear in close proximity merely on account of their being nearly in the same line of sight, though at different distances from the eye, and not because, revolving about each other in orbits, they constitute a binary system), occupy a certain position with respect to the ecliptic, and one of the components be very much nearer the earth than the other, a considerable periodical and parallactic change will take place in their angle of position, or the angle made with the meridian, by a line drawn through both of them, and that the maximum variation from the mean position will occur at two opposite seasons of the year. Lord Wrottesley determined to devote his equatorial to a good trial of this method of discovering parallax, and six years' uninterrupted observing, from February 1843 to October 1849, by his assistant and himself, was given to the work. But the observations were attended with great difficulties, and of sixty-nine double stars selected, only forty-eight were observed, and only nineteen at both periods of the year. Of these again, the observations of five only deserved much attention, as exhibiting indications of parallax measurable by this method; but two of them, 32 *Eridani* and 95 *Herschel*, Lord Wrottesley finally recommended to the notice of astronomers provided with adequate instruments for observing them. Thus the principal result of the labour and assiduity bestowed on this object was the illustration of the practical difficulty of the method, and it demonstrated the impolicy of further perseverance, with the instrumental means of the Wrottesley Observatory, especially as instruments had been erected, both at Liverpool and Oxford, pre-eminently suited to this class of observations. But the zeal which prompted the employment of so much time and force by one astronomer, in the pursuit of a mode of research, proposed to observers by another, deserves the commendation of every lover of science. The paper is worthy of attention in another point of view. The importance to the correction and advancement of knowledge of recording failures, and imperfect success in research, has been insisted upon by the highest authorities; modern astronomers have been conspicuous in acting on this principle, and have thus encouraged labourers in other departments to submit to the task so unpleasing to themselves, though so beneficial to their successors; and the candour with which Lord Wrottesley has estimated the amount of success obtained in this arduous inquiry, is equalled only by the devotion and skill displayed in making and discussing the observations.

When the Star-Catalogue of the British Association appeared, he was anxious to perform the same office in respect to that most

valuable publication which he had already undertaken and performed in reference to the prior Catalogue of the Astronomical Society. For this purpose he selected 1009 stars, with the intention of obtaining, at least, five observations of each, being those stars which had already been observed at Blackheath, and had been discovered to possess proper motion, with others selected on various accounts.

The observations were begun on the 1st January, 1850, and concluded on the 24th December, 1853. They were all made and computed by Lord Wrottesley's assistant, Mr. Richard Philpott, an excellent transit observer, aided in the computations by his second assistant, Mr. Frederic Morton, who had charge of the equatorial. The results were communicated to the Royal Astronomical Society, read on the 13th of January, 1854, and published in vol. xxiii. of the *Memoirs*, being alluded to with great approbation by the Council in the Report for February 9th, 1855.

On the resignation of the late Earl of Rosse, Lord Wrottesley was proposed and chosen President of the Royal Society, at the Anniversary Meeting of 1854, and was re-elected to that office in the three following years. Having thus been placed at the head of the most ancient and venerable of British scientific institutions, he availed himself of the first opportunity afforded him, according to established usage, of addressing the Royal Society, at the Anniversary of 1855, of taking a review of some of the desiderata of science in this country, with respect both to the wants of the public, and to the interest and encouragement of the nation and the government. In his address of 1856, he resumed the consideration of the requirements and actual condition of scientific knowledge, in connexion with the occupation of Burlington House by the Royal Society, in conjunction with the Linnean and Chemical Societies of London, to which an improved appreciation of science on the part of the existing administration had conduced.

In 1859, Lord Wrottesley communicated to the Proceedings of the Royal Society a paper, "On the Application of the Calculus of Probabilities to the result of measures of the Position and Distance of Double Stars." He remarked in this paper that the differences between mean results obtained on different evenings were greater in proportion than those of the separate or partial measures obtained on the same evening, which arose from chance errors of observation; and that this circumstance rendered the application of the formulæ of the calculus of probabilities to the reduction of the observations, embarrassing and difficult. The observations made after 1851 fully confirmed this anomaly. As the observations of his Catalogue of Double Stars were drawing to a close, and it became extremely desirable that if there were any fault in the reductions or method of computing hitherto employed, it should be speedily remedied and the necessary corrections made, he requested and obtained the opinion as to the best

mode of proceeding, of the Astronomer Royal, who proposed a formula adequate to the difficulties of the case, which is given in the paper, but which, though the correct one, he thought was too elaborate to use in dealing with observations in which the errors of observation were large in amount, and in which such extreme accuracy in the results is not attainable, as in some other cases to which the principles of the Calculus of Probabilities are applicable. Mr. Airy suggested, therefore, that all the observations of the several nights should be combined together for the purpose of obtaining the probable error and weight of the final result, which might be done in two ways. Lord Wrottesley accordingly proceeded to ascertain the result of employing each of these three methods, by directing his assistant, Mr. Morton, to observe three stars a very great number of times. The results are subjoined to the paper, together with the whole computation and a summary of them. "It is hoped," the author remarks, "that this may not only prove interesting to observers of double stars, but may throw some light on the curious mathematical question involved in the inquiry which is the subject of the above remarks." It appears from the entire investigation that little effect is produced on the mean result for each star by using these different methods of reduction.

The "Catalogue of the Positions and Distances of 398 Double Stars," for the sake of which the preceding discussions here recited were instituted, appeared in our *Memoirs*, vol. xxix., having been read May 11, 1860. In the introduction the author states that from the beginning of the year 1857, the final means were obtained, and the probable errors and weights computed, by considering all the observations of the star, on the different nights, to have been made on the same night.

The observations for the Catalogue were made by means of the equatorial telescope already noticed. As a general rule, ten measures, both in position and distance, were made on the same night of each object, whenever they could be obtained, but from March 1856 to October 1858 the practice was to take six measures only of each element. The ten or six observations, as the case may be, are called a set. There are, in fact, two Catalogues, the first containing the results of the observations of each star, made on separate nights; the second, the general mean of all the sets obtained in the same year.*

The production of this Catalogue appears to have been the last considerable work in Astronomy of Lord Wrottesley.

Lord Wrottesley married on the 28th of July, 1821, Sophia Elizabeth, third daughter of the late Thomas Gifford, Esq., of Chillington, Staffordshire, and had a numerous family; of whom two sons lost their lives in their country's military service.

Lord Wrottesley died at his ancestral residence on the 27th of October last, aged sixty-nine. E. W. B.

* This Catalogue is noticed in the Report of the Council for February 8, 1861.

Sir James South was the son of a pharmaceutical chemist who carried on business in Southwark in the latter half of the last century. He was born in October 1785. After an ordinary course of education he entered upon the study of surgery, became a member of the College of Surgeons, and acquired an extensive practice and a reputation that promised eminence had he followed the profession. It is probable that his tastes were turned towards astronomy through an acquaintance which he early formed with Captain Huddart, a famous engineer, who, among other achievements, had constructed an equatorial mounting for a telescope with an object-glass of $3\frac{3}{4}$ aperture, made by Dollond, which instrument subsequently came into Mr. South's possession. Before obtaining this he had procured a 6-inch Gregorian reflector, with which he observed eclipses, occultations, and other phenomena. In 1816 he married the niece and sole heiress of Joseph Ellis, Esq., of South Lambeth, and, no longer dependent upon his profession, resolved to devote himself entirely to astronomical pursuits. He at once set about the formation of an observatory at his house in Blackman Street, Borough, and furnished it with the Huddart instrument above alluded to, a second telescope of 5 inches aperture, and a transit made for him by Troughton, upon the model of that which this eminent maker had recently constructed for the Royal Observatory, Greenwich; it was of 4 inches aperture and 7 feet focus, and, in regard to the just proportion of its parts, Troughton considered it as his happiest production.

Intent upon the useful employment of his time and resources, Mr. South resolved upon re-observing the double stars discovered and measured by Sir William Herschel. This appeared desirable, not only for the purpose of detecting changes of position, but on account of the improvement that had been wrought in the construction of measuring instruments since the epoch of the elder Herschel's observations. Sir John Herschel had projected a similar repetition of measures. A concerted plan of work was therefore agreed upon, and the observers began their labours in 1821, and continued them during the two following years. The result was the well-known Catalogue of 380 Stars, which was presented to the Royal Society in 1824, and printed at the expense of the Board of Longitude, and which was the standard work of its class till it was rivalled by that of Struve. Our Society rewarded Messrs. Herschel and South, jointly, with the Gold Medal for their labours in producing this Catalogue, which was honoured in like manner by the French Institute. Mr. South now entered upon a second series of similar observations; but finding the situation of his observatory not so good as he could wish for delicate work, he, in the autumn of 1824, transferred his larger instrument to Passy, near Paris, and worked there till towards the close of the following year, accumulating measures of 458 additional double stars. Upon his return to England, he observed for a time in Sloane Street, and made a

re-examination of some of his French measures; this second Catalogue was printed in the *Philosophical Transactions* for 1826.

While working in concert with Sir John Herschel upon the first Catalogue he was using his transit instrument for an investigation bearing upon the errors of the Solar Tables then in use. The discordances between observed and calculated right ascensions of the Sun were generally attributed to instrumental inaccuracies caused by the heating of the instrument during the observations. Crucial tests were, therefore, instituted by Mr. South to verify or refute this supposition. For a time transits were taken with every possible precaution to shield the telescope from unnecessary exposure to sunshine. Then the sun was purposely allowed to shine upon one-half of the instrument for intervals varying from a few minutes to an hour before the time of transit, and series of observations were taken under these conditions. The observed places were compared with tabular places, and it was found from a mean of two years' observations that the difference between the errors derived from observations with the instrument defended and exposed amounted only to 0·045 of a second of time: it was, therefore, concluded that the discordances in question were not due to instrumental derangement, but belonged entirely to the tables. His paper on this subject and his labours upon double stars formed the grounds for the award of the Copley Medal to him in 1826.

The existence of an atmosphere of very great extent surrounding the planet *Mars* had been inferred from some observations by Cassini and Roemer, both of whom noted a considerable diminution in the brightness of a fifth-magnitude star occulted by the planet in 1672. This record prompted Mr. South to watch for appulses of *Mars* and stars, and he was fortunate in observing two near approaches and one actual occultation. In no case was any diminution of lustre or alteration of colour of the star detected beyond what was fairly attributable to the brightness and colour of the planet. Mr. South considered that his observations sufficiently negatived the conclusion derived from that of Cassini, but he commended the subject to further investigation, which, however, it has not received. In February 1821 he observed a remarkable occultation of δ *Piscium* by the Moon, when the star was projected to a considerable extent upon the unilluminated disk. This induced him to collect all available observations bearing upon the vexed question of projection. He analysed the recorded cases with reference to several explanatory hypotheses, viz. existence of a spurious disk in the Moon's image; existence of a lunar atmosphere; irradiation; imagination on the part of the observer; and differences of refrangibility of the light of Moon and star, arising from differences of colour. His examination led him to conclude that each and all of these were untenable, and he left the question where he found it, excepting that he had brought together a mass of materials to help any future investigator. The

Astronomer Royal, Mr. Airy, turned these to account, and increased the store: he took up the subject with a predilection for Mr. South's last-mentioned hypothesis, but finding it unsatisfactory, gave his adhesion to that attributing the apparent projection to irradiation in conjunction with some unexplained condition of the observer's mind or eye. This contribution of Mr. South's to astronomical literature appears in the *Memoirs* of our own Society, to which he had previously communicated several papers, relating to observations of comets and phenomena, adjustment of instruments, and methods of observation. Apart from his contributions to our *Memoirs*, the name of South will for ever be inseparable from the history of our Society; he was one of its founders, and, in the position of President, petitioner for the Charter by which, in 1831, it was incorporated. Immediately after procuring the charter, however, he ceased to take part in the Society's proceedings; the cause of his secession being a difference, into which it is needless to enter, concerning the tenure of the Presidency.

About the year 1826 Mr. South sought a better location for his instruments, and purchased a site at Campden Hill, Kensington, upon which he erected a magnificent Observatory, one of the most complete that private taste has yet called for. Besides the instruments removed from Blackman Street, it was furnished with the Transit Circle used by Groombridge in the formation of his Catalogue, and a clock presented by the King of Denmark. Mr. South intended to have a first-class equatorial, and procured from France a 12-inch object-glass by Cauchoix. A dome was prepared to receive the instrument, the manufacture of which was intrusted to Troughton, in whom South had unqualified confidence. The transaction was a very unfortunate one; the equatorial turned out, in South's opinion, a failure; bitter enmities were aroused, and the payment of the manufacturer became the subject of a lawsuit: the verdict was unfavourable to South, who forthwith demolished the instrument: every part of the mounting was broken up or mutilated beyond renovation, and the *débris* was sold as old metal by public auction. The object-glass was presented to the Dublin Observatory in 1862.

It was in 1831, while this instrument was in course of construction, that the honour of knighthood was conferred upon South, on the recommendation of the Duke of Wellington, then Prime Minister; subsequently a pension of 300*l.* a-year was granted for his contributions to Astronomical Science.

The unhappy affair of the equatorial in a great measure alienated Sir James South from astronomical pursuits. He published no more observations, but he did some work with his meridian instruments; he also devoted much time to experiments upon clocks and pendulums, the results of which may yet be rendered serviceable by publication. In 1846, when a line of railway was projected to pass near the Greenwich Observatory, of which establishment Sir James was a Visitor, he made a series of obser-

vations at Watford upon disturbances produced by passing trains upon the images of stars reflected from mercury; these were reported to the Government at the time, and were presented to the Royal Society in 1863.

Sir James South was the author of several papers and pamphlets of critical nature and severe tone. One of these, published in 1822, was an exposition of the then defective state of the *Nautical Almanac* as compared with the Continental Ephemerides: this subject received considerable discussion, and ultimately a committee was formed, with Sir James as its chairman, to report to the Admiralty upon it. To the recommendations of that committee the present excellence of the *Nautical Almanac* is due. The "Thirty-six Charges" preferred by South, in 1830, against the President and Council of the Royal Society were less satisfactory; although they were strongly pressed and freely circulated, they were never supported, and no notice was taken of them. He printed some minor papers in the *Quarterly Journal of Science* and *Phillips' Annals of Philosophy.*

During the last years of his life he was afflicted with nearly total deafness and partial blindness; bodily sufferings still further weighed him down till he sank beneath them on the 19th of October, 1867. J. C.

Alexander Dallas Bache was a great-grandson of the famous philosopher, Benjamin Franklin, and the son of Richard Bache, an able journalist. He was born at Philadelphia on the 19th of July, 1806. He graduated at the Military Academy at West Point, and at the end of the four years that determine the course of study at that institution, stood at the head of his class. The appointment of Assistant-Professor of Engineering in the Academy was immediately conferred upon him, but he held the chair for one year only. The education at West Point is gratuitous, but each cadet is expected to give eight years' service to the Government, unless he be sooner released: Bache served as a Lieutenant in the Corps of Topographical Engineers till 1827, when he was nominated to the Professorship of Natural Philosophy and Chemistry in the University of Pennsylvania. This post he occupied with distinguished success till the year 1836. The College and Asylum for Orphans, founded in Philadelphia by the princely bounty of Stephen Girard, was then springing into activity, and Professor Bache was made its President. Upon taking office he was at once deputed by the Trustees of the College to visit Europe, and inquire into the existing state of education in the schools of Great Britain and the Continent, especially those that bore similarity in objects and character to that under his control. Pursuing this mission, he made a tour through the important scholastic institutions of England and Scotland, France, Switzerland, Holland, Belgium, and the chief States of Germany; making also a rapid visit to Italy. Every detail of instruction and government was examined in the nume-

rous establishments of various classes that came under his inspection, and a large collection was made of text-books, instruments, models, drawings, and all other appliances for teaching that were likely to lend useful aid in fulfilling the wide intentions of the founder of the Girard Orphan School. The results of this inspection were embodied in a full and comprehensive report given to the world in the year 1839, and forming one of the most exhaustive summaries of orphan and general education ever produced, although it embraces but a portion of the materials that were collected for it.

During the Presidency of Professor Bache a Magnetic Observatory was established in connexion with this College, and, in 1840, a system of observations was commenced, in pursuance of the plan recommended by the British Association. Bache gratuitously directed these till his removal from Philadelphia in 1843, and after this he retained general superintendence of them till the series terminated in 1845. During the years 1840–41, he also made a detailed magnetic survey of Pennsylvania and the adjacent parts of New York, Ohio, and Maryland; determining the magnetic declination, dip, and intensity, at a number of stations suitably selected with regard to the course of isomagnetic lines. The discussion of these observations and of those made at Girard College were interrupted by the pressure of subsequent official duties, and were only completed after the lapse of many years.

In 1843 Dr. Bache entered upon that portion of his life's labours which has made his name famous throughout the scientific world. It was in 1807 that Congress passed an act authorising the Survey of the Coasts and Harbours of the United States. Plans of operation were invited from scientific men, and, of thirteen that were offered, one proposed by Mr. F. R. Hassler was accepted, its author being subsequently appointed to superintend the Survey. This he did with great zeal and ability, and the work might have been completed under his direction, but for its interruption for a period of nearly fifteen years, when he was in the prime of manhood and strength. Hassler died in 1843; Bache was at once appointed to succeed him. In entering upon his new duties, he expressed diffidence in his powers to do full justice to a work that his predecessor had created and made so peculiarly his own; but he resolved to apply himself to it with "entire devotion and unwearied energy," to quote his own words. The primary aim of the Coast Survey was to furnish, with the fullest possible accuracy, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and defence of the coast. For the first of these are necessary the fixation of geographical positions by accurate astronomical determinations, the measurement of bases, and primary and secondary triangulations; for the second, minute plane table surveys and contourings; for the third, soundings off the coasts and in the bays, harbours, and other navigable waters

connected with the ocean, the charting of shoals, rocks, &c., and the determinations of the direction and velocity of currents. These field operations involve heavy office work, reduction of observations, map-drawing, engraving, and printing. The scientific preparation, the practical knowledge, and the administrative talent, necessary for the successful conduct of operations of such magnitude and complexity could have been found in few men: it is not too much to say that Bache possessed all these requirements. The national work, great and important as it was when he took charge of it, grew in importance under his command. Old instruments and methods were replaced by others embodying modern principles and refinements: foremost among these may be mentioned the electrical determination of longitudes, which was employed between the principal stations of the Survey in 1845, and in many subsequent cases in which the existence of telegraphic communication rendered it possible. As the work progressed additional duties were undertaken; some, as the supervision of lighthouses, buoys, and beacons, imposed by the Government; others, self-imposed. By husbanding the strength at his disposal, Bache, who was a hard worker and genially encouraged hard work in others, widely extended the range of subjects originally embraced by the Survey: he organised magnetic observations, and recorded meteorological data, earthquake phenomena, and, for a time, the appearance of Sunspots. Although the principal share of his work will go to the furtherance of geographical knowledge, yet astronomy will indirectly benefit by it. Geodesy, too, will be advanced, for the Survey of the Atlantic Coast involves the measurement of an arc of latitude extending over twenty degrees. Terrestrial magnetism will profit by his extensive and systematic observations, and climatology by his comprehensive researches upon the movements of the Gulf Stream. His annual reports to Congress, increasing in extent and fulness as his labours neared completion, embrace an invaluable repertory of physical investigations, while they form a step-by-step history of the progress of a survey as certainly the most accurate as it is obviously the most extensive that has yet been produced or called for by any nation in the world.

Professor Bache contributed many memoirs, embodying the results of original researches in various branches of physical inquiry, to the American scientific journals, chiefly to *Silliman's Journal*, and the *Proceedings of the American Association for the Advancement of Science*. Of this Association he was twice President, and always a leading Member. He was an Associate of the principal learned Societies of Europe. In 1858 the Royal Geographical Society awarded him the Victoria or "Patron's" Medal for his labours in connexion with the Great Survey. When, in 1863, the National Academy of Sciences was established by Act of Congress to represent and direct the highest science of the country, the members of that body unanimously

elected him the first President for a period of six years. This period was unhappily cut short. His brain softened, it has been suggested from over-exertion, and, after a long and painful illness, he died at Newport, Rhode Island, on the 17th of February, 1867.

Wherever his name is mentioned it is coupled with expressions of admiration and respect. A high official of his Government said of him that "his genial disposition attracted the love of associates and subordinates: his wisdom commanded their respect. He leaves us a name of unsullied purity, and a memory that adds lustre to the many public records upon which it is borne." J. C.

The Rev. Henry Joseph Boone Nicholson, D.D., an honorary Canon of Rochester Cathedral, was the son of the Rev. J. Payer Nicholson, formerly Rector of St. Alban's, to which Incumbency Dr. Nicholson was himself instituted in the year 1835. He was elected a Fellow of this Society in 1825, and was also a Fellow of the Society of Antiquaries and of the Numismatic Society. His attention was chiefly directed to antiquarian pursuits, and his *Handbook to the Abbey of St. Alban's* is a very able work, showing not only his thorough acquaintance with the various styles of architecture exhibited in the building, but a large amount of varied historical research. He died July 27, 1866, at the age of 71, universally regretted.

The Rev. Miles Bland, D.D., F.R.S., was one of the first Fellows of the Astronomical Society. He was born on Oct. 11, 1786, at Sedbergh, in Yorkshire, where his family had resided for many generations. The Blands of Sedbergh appear, from Carlisle's *Collections for a History of the Ancient family of Bland*, to have been the original stock of the family. Carlisle writes (p. 2): "The family of Bland is purely English, and of very high antiquity. . . . Their surname is derived from Bland, or Bland's-Gill, a hamlet in the chapelry of Howgill, and Parish of Sedbergh." And he mentions William de Bland as doing good service to King Edward III. in his wars in France; Thomas de Blande and Robert de Blande as specially included in a proclamation of Sept. 25, 1386, and charged to take care that no arms or horses were sold to the king's enemies from the North Riding of Yorkshire; Patricius de Bland, of Sedbergh (p. 5), as one of some gentlemen appointed in 1333 to raise and command troops for an expedition against the Scots. Of the Sedbergh Blands was (p. 5) John Bland, Rector of Adisham in Kent, who had for a pupil at Adisham Edwin Sandys, afterwards Archbishop of York, and was one of the sufferers in Queen Mary's reign, having been burnt at Canterbury on July 12, 1555.

Miles Bland was educated at Sedbergh School, from which he went to St. John's College, Cambridge, in October 1804. Private tuition at Cambridge was then little known. The great

mathematical tutor of the day was Mr. John Dawson, a retired surgeon of Sedbergh, and a self-taught mathematician. Cambridge students went to read with him at Sedbergh in the summer vacations, and sent problems and questions to him from Cambridge for his solutions. Dr. Bland was wont to say that Mr. Dawson had had eleven Senior Wranglers for his pupils, and intended him to be the twelfth; but he was second, in 1808, to Bickersteth, afterwards Lord Langdale. Blomfield, afterwards Bishop of London, was third; and Sedgwick, the present Professor of Geology at Cambridge, and Bland's schoolfellow at Sedbergh, was fifth. Bland was elected Fellow of his College in 1808, and in 1809 was appointed Assistant Tutor, and continued in the tuition, first as Assistant Tutor, and afterwards as joint tutor with Mr. Hornbuckle, till 1823, when he took the College living of Lilley in Hertfordshire, and married. He was very highly appreciated by his pupils as a lecturer, and not less as a friend and adviser. He resided at Lilley till failing health obliged him to seek change of climate at Ramsgate. After some years he returned to Lilley, and resided there for thirteen years: but he was obliged again to leave it in 1852, and resided at Ramsgate ever after. He never held any other preferment than his living, except a prebend at Wells, little more than honorary. He was a Fellow of the Royal Society, and of the Antiquarian Society, and a member of the Royal Society of Literature. He published a collection of Geometrical Problems, with an Appendix on Plane Trigonometry, a Treatise on Hydrostatics, Mechanical Problems, Problems in the different branches of Philosophy, and Algebraical Problems, better known as *Bland's Equations*, which have exercised the ingenuity of many a young mathematician. This last publication passed through many editions. A translation of it was published at Halle so recently as 1857. He drew up also Annotations on the Historical Books of the New Testament, but did not proceed with the publication of them beyond the Gospels of St. Matthew and St. Mark. His vigour of mind and keen interest in everything that passed, and particularly in all that affected his University and his College, he retained to the end of his life. He died of old age, without disease and without suffering, on Dec. 27, 1867, at the age of 81 years.

James John Downes, Esq., was born of humble parentage, on October 18, 1790. With indomitable energy he succeeded in qualifying himself for the position of mathematical tutor and lecturer on science. Among his pupils were several who afterwards obtained considerable reputation as mathematicians, while his originality of thought and skill in demonstration procured for him celebrity as a lecturer. In 1832 he was elected, after a strict examination, from upwards of thirty candidates, to fill the office of Actuary to the Economic Life Assurance Society. He performed the duties of this office with much ability and zeal for

a period of thirty years, when he retired into private life, carrying with him the esteem and respect of all with whom he had been officially associated. He died on November 12, 1867, beloved and respected by a wide circle of friends. He was a Member of the old Mathematical Society, and for some time officiated as Secretary. He published a small Handbook of Algebra, which is now out of print. He became a Fellow of our Society in 1837, and took an active part in the transfer of the old Mathematical Society and its valuable library to the Royal Astronomical Society.

Charles Howell, Esq., died at Hove, near Brighton, on December 8th, 1867, aged 84 years. He was elected a Fellow of our Society in 1857. He inherited from his father an ample fortune and devoted his early life, with much zeal, to nautical and agricultural pursuits. He was always attached to the use of the telescope, but it was not till he was far advanced in life that he built an observatory, furnished with excellent instruments, at Hove.

Mr. Howell's astronomical observations were chiefly of planets and of double stars. When by reason of advancing years he had become unfitted to employ himself in his observatory, he generously opened it to the unrestricted use of his numerous friends, and also for the purposes of education, in the hope thereby to enkindle in youthful minds a love of that science which he so ardently admired.

One of his last acts was to erect upon a valuable piece of ground in the centre of Brighton a range of almshouses which he has bequeathed for the use of the poor of that town. He died universally respected, and the poor deplore the loss of a truly benevolent and tender-hearted man.

Mr. William Brooke was born at Burnham Market, in Norfolk, on August 1st, 1795. His education at the outset was such as in remote provincial towns in those days was the only one accessible to the middle classes. But he was from his earliest years studious, and qualified himself to enter a private school kept by a Mr. Shrimshire, the Incumbent of North Creek, where he devoted himself to classical reading with so much assiduity as in a large degree to make up for his want of a public-school training. About the year 1820 he opened a school at Norwich, which he continued until age made it needful for him to retire from an occupation in which he had been engaged with much honour and a fair share of success for about forty-five years. Not a few of his pupils have acknowledged with gratitude the benefit they derived from his lectures on Experimental Science. This was before the appointment of Professor Sedgwick as Canon of the Cathedral, and the elevation of Bishop Stanley to the See of Norwich. These events greatly stimulated the scientific activity of the city, and Mr. Brooke was soon found in the front

ranks of a considerable and energetic band of inquirers and observers,—a position which he maintained to the end of his life. His meteorological observations were commenced before 1830; the records he kept and supplied to the local papers and to scientific journals. Mr. Brooke was elected a Fellow of our Society in 1849. In 1850 he joined the Meteorological Society. He died upon his natal day in 1867, aged 72 years, leaving behind him, in a wide circle of friends, the memory of a blameless and well-spent life.

Proceedings of various Observatories.

Royal Observatory, Greenwich.

The work of the past year has been of the usual character: comprising observations of the Sun, Moon, and principal planets, at every opportunity on the meridian; observations of the Moon with the Altazimuth extended as near conjunction as possible; and continuous observation of the principal stars.

The re-observation of Bradley's Stars contained in Bessel's *Fundamenta* has been completed, and it is intended to incorporate in a catalogue the results of the star-observations from 1861 to 1867 inclusive.

For the reduction of the Observations in 1868, the refractions will be computed with the mean refractions of Bessel's *Fundamenta* diminished in the proportion of

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combined with the meteorological corrections of the *Tabulæ Regiomontanæ*. The colatitude adopted is $38^{\circ}\ 31'\ 21''{\cdot}60$. These changes have been made on the authority of Mr. Stone's paper in the *Monthly Notices* for Dec. 13th.

The piercing of the central cube of the Transit-Circle to allow of the adjustment of the wires of the collimating telescopes without raising the Transit-Circle has been followed by a change in sign of the astronomical flexure of the telescope. It has been found that the sign of the law of discordance between the direct and reflexion observations has changed, in 1866, with the change of sign in the astronomical flexure of the telescope; the resulting value of the colatitude is in satisfactory agreement with values previously obtained. It is probable that this will throw considerable light upon the origin of the discordances between the observations of stars in zenith distance directly and by reflexion at the surface of quicksilver.

The middle room of the Great Equatorial Dome has been

rendered fire-proof and will be used as a room for the deposit and trial of chronometers.

The greater part of the volume for 1866 has been passed through the press, and the reductions of the Observations for 1867 are complete and the results nearly ready for the printer.

Royal Observatory, Edinburgh.

The work performed here during the past year has not materially deviated from the usual Star Observations with the Transit Instrument and Mural Circle; public time-signals, with electric controlled clock superintendence; and the computations of meteorological observations from fifty-five observing stations of the Scottish Meteorological Society, the results being printed and published monthly or quarterly by the Registrar-General of Births, Deaths, &c. in Scotland. None of the additional accommodation so urgently required for the performance of this work has yet been supplied; and there is now a negotiation in progress for giving to the Royal Observatory, Edinburgh, the observations of seventeen more meteorological stations to compute every month, making seventy-two of such stations in all.

Radcliffe Observatory.

The subjects of observation at the Radcliffe Observatory, Oxford, were essentially the same for the past year as for those immediately preceding. The star-list includes the stars necessary for the completion of the re-observation of those which require it in the Catalogue of the British Association, and stars between the sixth and eighth magnitudes, lying chiefly between 50° and 70° of North Polar Distance, selected from various Catalogues. The Sun, as in former years, has been observed whenever it has been practicable, though the state of the sky has been, on the whole, nearly as bad as in the year 1866. The Moon has been observed in each lunation till the first transit (inclusive) after opposition; and *Mercury* and *Mars* whenever it has been practicable. The number of stars observed generally in both elements in 1867 is 1453; while, of the Sun, 92 observations have been made, of the Moon 56 observations, of *Mercury* 34, and of *Mars* 17 observations. The whole number of transits amounts to 2472, and of North Polar Distances to 2314. The number of good evenings for observation was, as in the year 1866, small.

The heliometer has been employed by Mr. Main, as in preceding years, for the observation of double stars. In connexion with this instrument it may be mentioned that, after a little correspondence with Mr. Merz, the maker of the object-glass, Mr. Main succeeded in separating the crown and flint lenses of the

segments of the object-glass, and, after cleaning their inner surfaces carefully, in fastening them together again, without detriment to the goodness of the images. Some additional transits of circumpolar stars were taken in the autumn, during some hot weather, for the re-determination of the value of the screw, by which it appears that that which has been in use for several years is sensibly accurate.

The reductions of the astronomical observations have been kept up with the same rigour as in the preceding years. The transits were perfectly reduced and ready for transcription into the ledgers, at the close of the year, and the North Polar Distances are now nearly completed. As in former years this has entailed very heavy personal labours on the Director.

The beginning of the solar eclipse of 1867, March 5–6, was well observed by three observers; the observation of the termination was prevented by clouds. A few observations of occultations of stars have also been made.

The printing of the Astronomical Results of observations for 1865 has been completed for some time, and copies were sent to a few of the chief astronomers in Great Britain; the printing of the Astronomical Results for 1866 is proceeding steadily.

The Meteorological reductions are, as in the preceding years, considerably in arrear, those for 1865 being not nearly completed. Their utility is, however, such, that the Director is unwilling to give up, for the present, at least, any of the discussions which have been carried out in former years.

Recently Mr. Baxendell has made some interesting deductions from the observations of solar radiation, by which it appears extremely probable that there is a periodicity of solar radiation synchronizing with the periodicity of the solar spots. Mr. Baxendell's discussions will at least give a value to observations of solar radiation which did not appear to belong to them before, and probably induce private observers to bestow greater care and attention on them.

In addition to the ordinary labours of the Observatory which have been detailed, a great deal of work has been done during the past year towards the compilation of the *Second Radcliffe Catalogue of Stars*. This is now in a very forward state. The results for the different years have been all combined in one catalogue, and reduced to the proposed epoch 1860; and the annual precessions and secular variations for that epoch have been computed. The Catalogue itself has been formed, containing very nearly 2400 stars (observed between 1855 and 1861, both inclusive), and the precessions and secular variations are transcribed into it. Very little remains to be done, but the combination of the observations in the different years, and the application of the corrections which may be considered necessary, as the result of the discussions which are connected with the work. It is expected that the Catalogue will be printed and published in the course of the present year.

Cambridge Observatory.

In addition to the ordinary transit and circle observations, the accurate determination of the places of those stars, selected from Oeltzen's List, in which the comparison of Lalande and Argelander seems to indicate large proper motion, has been constantly kept in view. These observations are now all but completed, and great progress has been made in the reductions. The true apparent right ascensions are obtained to May, 1867, and the true North Polar distances to the end of 1866. The reductions to the mean place for the beginning of the year are calculated to the end of 1866.

The equations of condition from occultations of fixed stars by the Moon, are calculated to the end of 1866, and equatorial observations of Comets are nearly all reduced.

The copy for the press is in progress, and will very shortly be in a sufficiently advanced state to be put into the hands of the printer.

The velocity of the wind has been measured by the Robinson's anemometer, which has worked satisfactorily, and a new and very sensitive vane has been erected.

All the meteorological observations have been regularly taken at the hours of 9 A.M., and 3 P.M., and more frequently in heavy storms.

A watch was kept for the November meteors, but the night was unfavourable, and very few were observed.

A small universal instrument, of beautiful workmanship, by Ertel of Munich, the property of the late Mr. Cooper, of Markree, has been secured for this Observatory.

Mr. Simms has made great progress in the construction of a new meridian circle for this Observatory, which is to be erected in the place of the present transit instrument. The circle is three feet in diameter, and the telescope is eight inches in aperture, and about nine feet in focal length. An excellent object-glass by Mr. Cooke, which has been already thoroughly tested by Mr. Dawes, has been purchased for it. The cost of the instrument is to be defrayed out of the Special Fund presented to the University by Miss Sheepshanks for the benefit of the Observatory.

The New Liverpool Observatory, Bidston, Birkenhead.

During the early part of last year the difference of longitude between the old Observatory on the east and the new Observatory on the west side of the Mersey, was found by the transmission of sixty chronometers to be $17^{s}\cdot04$. From this determination the longitude of the new Observatory is $12^{m}\ 17^{s}\cdot15$ West of Greenwich. In remounting the transit instrument of five feet focal length and four inches aperture, provision has been made for

using it either in the meridian or in the prime vertical. From five transits of *β Draconis*, four of *γ Draconis*, and one of *α Cygni*, each of them over the east and west prime verticals, the latitude is 53° 24′ 3″·8 N. or 44″·0 South of the old Observatory. By ten simultaneous readings of barometers at the two stations the height of the cistern of the standard at the new Observatory is 212 feet above the mean level of the sea, and 175 feet higher than it was at the old Observatory. The mean temperature for the year is 1°·4 lower at the new than at the old Observatory, as obtained from simultaneous daily readings of thermometers at the two stations during two years. The equatorial of twelve feet focal length and eight and a half inches aperture has been re-erected by Messrs. Troughton and Simms, under a dome of twenty feet diameter. The old transit-clock is placed in a cellar, twenty-four feet below the ground-floor of the building, and clocks controlled by it are placed in the transit and equatorial rooms. A new clock and spring-governor chronograph, made by Messrs. Bond and Son, of Boston, U.S., have recently been erected in a room contiguous to the transit and equatorial rooms. A clock regulated to Greenwich mean time, placed in the chronometer-room, controls one clock in the deep underground cellar, and another on the margin of the river near the Birkenhead Landing-stage; the latter controlled seconds clock, the face of which is exposed to public view, fires a time-gun daily at 1 P.M. An observer in the chronometer-room, within hearing of the beat of the normal clock, never fails to see the flash of the gun on a clear day, and in foggy weather, when the flash cannot be seen, the sound is heard at twelve seconds after 1 P.M. within a small fraction of a second. This mode of communicating time to the port and towns of Liverpool and Birkenhead is already very highly appreciated. The contact springs for the transmission of galvanic currents applied by Messrs. Ritchie and Son, of Edinburgh, to the sidereal and mean time clocks have not affected the regularity of their performance; the rates of both clocks have been much more uniform than they were at the old Observatory; but, in all probability, this is mainly due to their being placed in rooms in which the change of temperature during the year is very small. At the old Observatory, chronometers could only be tested during six or seven months of the year through the range of temperature to which merchant ships are generally exposed; in the new Observatory, during the past twelve months, the chronometers have been exposed on alternate weeks to the temperatures of 55°, 70°, 85°, 70°, and 55°, in regular succession throughout the year, so that in five weeks a chronometer can now be tested efficiently at any time of the year. The Observatory will in a short time be supplied with the means of testing various other nautical instruments in addition to chronometers.

Glasgow Observatory.

At the Glasgow Observatory the astronomical observations during the past year have been similar in character to those of previous years. The Transit Circle has been regularly employed in the observation of a select number of stars chiefly comprised between the fifth and eighth magnitudes. The Ochtertyre Equatorial continues to be used on every available occasion for the measurement of double stars. Correct time is transmitted to the City and Port of Glasgow, as in former years, by means of Jones's well-tried invention of the controlling of clocks by electricity.

The meteorological operations at the Observatory have acquired an important extension since the date of the last Report of the Council. It is generally known that the Board of Trade has recently assigned the superintendence of the meteorological operations of that department to a Committee of men of science, at the head of which is the President of the Royal Society, and that, among other recommendations of the Committee, has been the establishment of a definite number of stations distributed over the British Isles, furnished with self-recording instruments for ascertaining the continuous variations of the weather, and more especially for obtaining an exact determination of the facts connected with the occurrence of storms.

The Glasgow Observatory having been one of the stations nominated for this purpose, has been recently furnished with a complete system of self-recording instruments, the operations with which commenced on January 1 of the present year. It is hardly necessary to state that the Government has undertaken to defray the expenses connected with the fitting up of the instruments and the conducting of the subsequent operations.

Kew Observatory.

The regular progress of the work of the Kew Photoheliograph has somewhat suffered this year from two causes; one being the unfavourable state of the weather, which not only diminished considerably the opportunities for taking photograms, but also interfered with the usually excellent definition of the details in the Sun's appearance. The other cause was the interruption of the work from August 9 to September 9, in consequence of necessary repairs to the dome of the Observatory. There was therefore a falling off in the number of observed groups as compared with those registered by Hofrath Schwabe, by five groups, of which three must be accounted for by the difference of climate, while two groups have been observed in Dessau during the total interruption of the work at Kew. On the whole, there were 130 days of observation, on which 188 Sun-pictures were taken.

The work of reducing the observations, however, has not only been carried on with the greatest vigour, but former investigations have been extended on the basis of the Kew photograms, and steps have been taken to arrive at trustworthy results with reference to the important question of the influence of optical distortion on the observation-elements supplied by celestial photography generally and the Kew Photoheliograph specially.

The authors of the *Researches on Solar Physics*, Messrs. Warren De La Rue, Balfour Stewart, and Benjamin Loewy, announce that the third series of these is completed, and will probably be ready for the printer in a few weeks. They give in this paper, to which about 100 pages of tables are added, the following information:—

1st. A full description of the methods employed in the measurement and reduction of solar photograms, for determining the heliographical longitude and latitude of Sun-spots, with the view of deducing from them the elements of rotation of the Sun and the inclination of the solar equator to the plane of the ecliptic; also the final results, giving the heliographical elements of all Sun-spots observed in 1862 and 1863. This part may in a measure be regarded as a continuation of Mr. Carrington's results.

2nd. The results of the area measurement of all Sun-spots observed in 1862 and 1863, forming a continuation of their results published in Series II. of the *Researches*, which were founded on Mr. Carrington's drawings.

3rd. An account of some preliminary experiments undertaken to determine the amount of optical distortion in the photograms obtained with the Kew Photoheliograph.

4th. An inquiry into the distribution of spots in latitude, extending their former researches, which had only the ecliptical longitude in view, and adducing additional evidence for attributing to the planet *Venus* a preponderant influence on solar activity.

The plan for the work of the present year comprises the continuation of the astronomical work and application of the results to a new determination of the solar elements; area measurements of all Hofrath Schwabe's Sun-pictures, for establishing a more trustworthy curve of periodicity; the extension of their researches into the physical phenomena on the Sun based on these results; a repetition of the investigations on the distortion of the photographic image with more refined methods; and, finally, hopes are entertained that regular observations of the heating and actinic effects of the Sun may be set on foot.

Lord Rosse's Observatory.

The most remarkable amongst the recent observations made at Birr Castle is the discovery in four nebulæ of a more or less marked spiral arrangement.

These nebulæ are indicated by the following numbers in Sir John Herschel's General Catalogue : —

1519, 1520 } Double Nebula, 385, 386 } Double Nebula, 1596, 2708

As the work on the Great Nebula in *Orion* was allowed to take precedence of other work, fewer observations on the nebulæ generally were made during the last year than would have been made under other circumstances; but from September 1866 to April 1867 more than 300 observations were recorded.

When the clock movement for the great reflector, which is now in progress, is finished, Lord Rosse intends to make further spectroscopic observations, and to try lunar photography, which was attempted, though with little success, some years ago, when the art was in a less perfect state.

Mr. De La Rue's Observatory at Cranford.

The past year has been remarkably unpropitious for the work carried on at this Observatory, for not only has the sky been overcast for a greater number of days than usual, but also the atmosphere has been very much disturbed on most occasions when astronomical photography could be attempted. This state of things has caused considerable perplexity, because two astronomers desirous of obtaining instruction in astronomical photography have had very considerable difficulty in obtaining the requisite opportunities for so doing. Mr. Le Sueur stayed at Cranford for some time during the month of February, and, by dint of great perseverance and watching for opportunities, was enabled to make lunar photographs on several occasions, and to thoroughly familiarise himself with the operations of astronomical photography. Notably on Feb. 22, Mr. Le Sueur, aided by Mr. Reynolds (photographic and mechanical assistant at Cranford), obtained a photograph of the Moon, of remarkable sharpness. Mr. Le Sueur, it is known, will have charge of the great Melbourne Telescope, which has been made by Mr. Grubb of Dublin, under the superintendence of the late Lord Rosse, Dr. Robinson, and Mr. De La Rue. Major Tennant, who will conduct the observations of the total solar eclipse in India on August 18th, which have been promoted by our Society, has also received instruction at Cranford, where he resided for some days on three occasions. On the first occasion, he was unable to obtain any opportunity for photography; in September, however, he was more fortunate, and took part on the 13th of that month in the photographic records of the lunar eclipse which occurred on that day. In December, Major Tennant was accompanied by the Sappers who had been detailed for the eclipse operations in India. The party consisted of Sergeant-Major Phillips and two Sappers. They thoroughly familiarised themselves with the working of the equatorial and the details of

the photographic operations performed with it; they also received instruction in enlarging photographs, and in etching them on glass, as detailed in Mr. De La Rue's Bakerian Lecture on the Solar Eclipse of 1860, published in the *Philosophical Transactions* for 1862. Major Tennant and his party therefore start with all the experience which has accrued from Mr. De La Rue's work in 1860–61; and if the weather prove propitious, it may fairly be expected that valuable records will be obtained by him and his staff.

Mr. De La Rue has received two silvered-glass mirrors from Mr. With; the first, although very good, was not considered by him to be equal to the metal mirrors figured by himself. The second, which has only been recently received, Mr. With believes to be very superior to the first made by him for the Cranford Observatory: but the weather has not yet permitted a fair testing of its performance.

Mr. De La Rue intends taking up again experiments in the figuring of specula; for which object his polishing machine has been removed from London to Cranford, where a small steam-engine has been erected. Hitherto, the polisher has been circular, and of nearly the same diameter as the speculum to be polished; it is evident, however, that a convex paraboloid of revolution can only fit exactly in a concave paraboloid so long as their axes coincide, which can only occur rarely during the operation of polishing. Three points, however, would touch a concave paraboloid in any part of the curve; although three mere points could not be used as a polisher, three small disks of pitch may be so employed, and it is assumed that by the use of a polisher so constructed, better figures may be obtained than heretofore:—it is in this direction that Mr. De La Rue's operations will be conducted.

Mr. Huggins' Observatory.

From the results of *spectroscopic* research at this Observatory during the past year, the following observations may be selected for mention.

The spectrum of *Mars* was carefully re-examined, but as this investigation has appeared in the *Notices* of the Society, it is not needful to give any details here.

On December 5, Mr. Huggins subjected the spectrum of the planet *Neptune* to a careful scrutiny, but was unable to detect any unusual lines of absorption which might account for the strongly marked blue colour of this planet. The faintness of its spectrum does not permit any great value to be attached to this negative result.

The comets visible during the year were too feeble in brightness to admit of the successful application of the prism. On two occasions, however, the spectrum of Comet II. was believed to be similar to that of Comet I. 1866.

The spectra of the stars η and μ *Geminorum* were examined in April. They were found to resemble very closely that of α *Orionis*, though there is apparently a somewhat different relative intensity of the lines.

During June, the spectrum of α *Herculis* was carefully examined, and the remarkably arranged groups of lines were remeasured. These observations agree with the measures and comparisons of the chemical elements of this star obtained in 1863.

Mira Ceti, which gives a spectrum apparently identical, or nearly so, with α *Orionis*, was examined when at its maximum brilliancy, and on several subsequent occasions, after it had commenced its downward curve. At the time the star was waning in brightness there was an appearance of greater intensity in several of the groups, but a continued series of observations is desirable, before any opinion is hazarded as to the cause of the variation in brightness which has procured for this object the title of "Wonderful." At Mr. Baxendell's request the variable R *Coronæ* was examined when at its maximum in the autumn, but without any successful result.

Mr. Huggins has confirmed the observations of MM. Wolf and Rayet so far as to the presence of bright lines in the three small stars described by them. He has not determined the number and positions of these lines.

During the year several attempts have been made to obtain a useful spectrum of the Milky Way. The spectra of the minute stars which are separately visible in his telescope were all continuous, but the spectra of unresolved portions could not be determined with certainty. There appears to be great probability, from their faintness, that these spectra are also continuous, for if they had consisted of a few bright lines, they would probably have been of manageable brightness.

The lunar object, *Linné*, has been observed and measured on every favourable opportunity during the year. The results obtained up to June are contained in the *Monthly Notices* for that month. Numerous observations have been obtained since, but Mr. Huggins is not prepared to make any further statement at present.

A few occasions of unusual atmospheric clearness were employed to re-examine and measure the bright granules of the solar surface. These views and measures confirm in every particular Mr. Huggins' description of these bodies in the *Notices* for May 1866.

Mr. Huggins has succeeded in constructing a new spectroscope, by which he is enabled to bring to bear on the celestial bodies an amount of dispersive power several times greater than has hitherto been applied to them. In this instrument the prisms employed have a dispersive power equal to about seven prisms of dense flint-glass of 60°. This instrument is found to be quite manageable even upon the nebulæ, and with it the bright

lines of the Great Nebula in *Orion* and of some other nebulæ have been compared directly with the bright lines of terrestrial elements.

Mr. Huggins intends to make use of this instrument in the continuation of his observations on the spectra of different parts of the Sun's surface, and of the solar spots. He has already insulated the spectrum of the umbra of a spot. These observations are in progress.

During the last two years Mr. Huggins has made numerous observations for the purpose of obtaining a view, if possible, of the red prominences seen during a solar eclipse. The invisibility of these objects at ordinary times is supposed to arise from the illumination of our atmosphere. If these bodies are gaseous, their spectra would consist of bright lines. With a powerful spectroscope the light reflected from our atmosphere near the Sun's edge would be greatly reduced in intensity by the dispersion of the prisms, while the bright lines of the prominences, if such be present, would remain, but little diminished in brilliancy. This principle has been carried out by various forms of prismatic apparatus, and also by other contrivances, but hitherto, however, without success.

The Progress of Astronomy during the past Year.

We have not, as on some former occasions, to record any remarkable and salient discoveries which will make the past year memorable in the annals of the science of Astronomy; but still, in the great activity which has been displayed by the cultivators of all its branches, we may see bright indications of sure and steady progress. Some of the labour of the past year has been spent in the form of preparation, the fruits of which, it is to be expected, will enrich the roll of discovery and research of the present and many succeeding years. Expeditions furnished with elaborate instruments have been originated and sent on their way to a distant country, for the purpose of learning as much as possible from the phenomena of a remarkable solar eclipse. Rapid progress has been made towards the completion of two magnificent telescopes, both of which will probably leave our shores during the present year.

We proceed to notice these and some other matters of prominent interest to the science of Astronomy.

The Total Solar Eclipse of August 17, 1868.

The present year will be signalised by a total solar eclipse of almost the greatest possible duration. As probably centuries may elapse before we shall have again an opportunity so excep-

tionably favourable for observing the peculiar phenomena which are only to be seen during a total eclipse of the Sun, it will be a source of gratification to the Fellows of the Society that two well-equipped expeditions have already proceeded to India for the purpose of making observations during the eclipse of August next.

One of these expeditions was originated by our Society.

Two letters of Major Tennant's, one published in the *Notices* of this Society for January, 1867, and the other forwarded to our Secretary early in February, but (owing to the Annual Meeting) only published in March, drew attention to the remarkable Total Eclipse of August 18, 1868. At their Meeting in March the Council accordingly appointed a Committee, consisting of the President, the Astronomer Royal, Mr. De La Rue, Maj.-Gen. Shortrede, and Col. Strange, to forward, if possible, the object of making observations during the very long obscuration of the Sun. It was decided that an application should be made to the India Office to bear the expenses of establishment and instrumental means, and that a silvered glass mirror should be mounted equatorially for photography, and that two telescopes kindly lent by the Astronomer Royal should be fitted for spectroscopic and polarization experiments. Estimates were submitted for the cost of instruments through the Astronomer Royal, and on the 15th July, sanction having been received for the cost, the instruments were ordered. Major Tennant proposed that he should be aided by Capt. Branfill, of the Great Trigonometrical Survey, and Lieut. Herschel, R.E., of the same department (who, however, has since undertaken a commission from the Royal Society), and that three men of the Royal Engineers should be trained to carry out the photographic operations. After some considerable delay, the expense was sanctioned, the Treasury having consented to bear half the amount. The delay had expended Major Tennant's leave of absence from India, and as much remained to be done, he was, on the matter being represented to the Secretary of State for India, detained at home on duty to superintend the preparations and the instruction of operators. Before proposing officially to employ men from the Royal Engineers, Major Tennant believed he had satisfactorily ascertained that there would be no difficulty as to their services being available; but an unexpected one arose, and it was fortunate that he was on the spot to remove them. He was cordially aided at the India Office by Mr. Arthur Hobhouse, who throughout has taken a personal interest in these observations, and assisted in every way to remove obstructions and avoid delays. On the 10th December Sergeant Phillips and Sappers Talbot and Conway, of the Royal Engineers, went to Cranford, where, by Mr. De La Rue's kindness, they went through the whole of the processes of taking the small negatives, enlarging, and etching them on glass. Major Tennant had gained some previous experience from several visits at Cranford since April last, and, though unfortunate generally in the weather, he had assisted at

photographing the lunar eclipse on Sept. 13. The proposed photographic operations differ from those formerly undertaken by Mr. De La Rue in Spain, where the Kew Photoheliograph was used, and the image of the Sun, in the focus of the object-glass, was enlarged by a suitable eye-piece before falling on the sensitive plate. It is now proposed to use a reflecting telescope (which ensures absolute identity of the actinic and visual foci) and to place the plate in the principal focus of the great speculum. The form is Newtonian, and the image being taken at the side of the tube allows room for a larger plate than could be placed in the centre of the tube; this is of great importance, as it is desirable to obtain as much of the corona as possible. The whole has been constructed by Mr. Browning, who has devoted to it a very great amount of time and care, with the advantage of the advice and experience of Mr. De La Rue. It is very satisfactory to know that the process of photographing celestial phenomena has been so completely mastered by Mr. De La Rue, that ordinary photographers can be taught in a few hours to use his apparatus with success.

In a paper printed in the Supplementary Number of our *Notices* Major Tennant, in view of his then immediate departure for India, described the apparatus which was in preparation. On Nov. 9, the Council were enabled, through the kindness of Mr. Howlett (who waved his claim on the instrument) to lend the Sheepshanks Telescope, No. 3, and by a grant from our funds to have it so modified as to enable this instrument to be used in the low latitude in which the eclipse is visible as total. Major Tennant, having thus an equatorial with clockwork motion, has transferred to it the spectroscope made by Mr. Simms, and has adapted the polarization apparatus made by Mr. Ladd to the telescope from Greenwich, which was equatorially mounted by Mr. Simms for the spectroscope, as described in the paper referred to. The facilities for observing have, of course, been thus greatly increased. In the arrangement of the spectroscopic and polarization apparatus, Major Tennant desires to acknowledge the aid he has received from the Astronomer Royal and our Secretary, Mr. Huggins.

The other expedition has been sent out by the Royal Society, and the necessary instruments provided out of the Parliamentary grant annually placed at the disposal of that Society.

The superintendent of this expedition, Lieut. John Herschel, R.E., an assistant in the Great Trigonometrical Survey, and a son of Sir John Herschel, has been instructed to confine his attention to observations of the spectra of the corona and red prominences, and to an examination of the light of these objects for polarization. He is provided with instruments suitable for these observations. The telescope for the spectrum observations has an aperture of five inches, and an equatorial mounting. It is furnished with a superior driving clock, the rate of which is maintained uniform by a form of pendulum-governor recently invented by Messrs.

Cooke and Sons, by whom the whole instrument was constructed. It is provided with a complete spectroscope constructed by Messrs. Simms.

For the observations for polarized light there is a second telescope of three inches aperture, furnished with two analyzers. The observer is instructed to use, first, a double-image prism, and a plate of quartz cut perpendicularly to the axis. If only a small amount of polarised light be present, it will be shown by the complimentary tints of the images. The second analyzer, consisting of a Nicol's prism and a compound plate of quartz, showing Savart's bands, may then possibly be employed with advantage to determine the position of the plane in which the light is polarized.

In addition to these instruments, four hand spectrum-telescopes of the form constructed by Mr. Huggins for the observation of meteors,* have been sent out for use by observers stationed at different places along the central line of the eclipse.

It will be, doubtless, of interest to our Society to know that Lieut. Herschel has been recommended to apply himself, as far as his other arrangements may permit, after his arrival in India, until the period of the eclipse, to the extremely important work of a prismatic examination of the brightest of the Southern Nebulæ. For these observations the instruments at his disposal are perfectly suitable.

Unless the weather should be unfavourable at both the stations selected by the two expeditions, we may confidently anticipate results of great value to our knowledge of solar physics from the carefully considered observations which are proposed to be made in August next.

This may be a suitable place to call attention to an observation of a red prominence made during the annular eclipse of March 6, 1867. Dr. Weiss, who accompanied an expedition into Dalmatia, where the eclipse was annular, has placed on record the following observation of Ensign Kiha, who was stationed about $2\frac{1}{2}$ geographical miles north-west of Ragusa. He made use of a telescope of 2-inches aperture, furnished with an eyepiece magnifying 40 diameters. 14·4 minutes before the annulus was formed he saw a protuberance which, with some interruptions from clouds, he kept in view until 14·7 minutes after the formation of the ring. When first detected, the prominence was already a striking object, and it disappeared, not through excessive faintness, but in consequence of the passage of a cloud. Kiha described the object to be of the form of a small flame, and to have a brownish yellow colour. It was marked in the direction of its length by stripes of a deeper tint of the same colour. The observations of the protuberance show that it could not have had any connexion with the Moon.

* See "Proceedings, Royal Society," vol. xvi., p. 241.

It is certainly important that these phenomena should be looked for on every occasion which may possibly favour their visibility.

On the Possible Influence of the Tides on the Position of the Earth's Axis.

The question, so highly important under many aspects, of the possible effects during the past history of the Earth of the frictional action connected with the tides, has been carefully discussed by Mr. Stone, in reference to the possibility of the production by this action of a secular change in the position of the Earth's axis of rotation. Mr. Stone investigates this action upon two distinct hypotheses. He first takes the frictional action to be equivalent to a couple whose intensity is proportional to the existing angular velocity, and whose axis coincides with the instantaneous axis. Secondly, he supposes that the tidal action may be represented by a couple of resistance with its axis perpendicular to the plane of the ecliptic and proportional to the relative angular velocity of the Earth and Moon on this plane. The exceeding slowness of the resulting secular changes would appear to remove the tidal action from the direct causes to which we may look for those great secular changes of climate which geology has shown to have succeeded each other upon the surface of the Earth.

Star Catalogues.

The observations of stars made with the Meridian Circle of the Bonn Observatory from the year 1845 to the beginning of the year 1867, have been collected by Dr. Argelander into a catalogue, the epoch of which is 1855. This valuable Catalogue contains accurate places of most of the known variables. The total number of star places contained in the Catalogue is 33811.

Mr. Ellery, the Director of the Melbourne Observatory, has published his star observations made during the year 1863, 1864, and 1865. These observations are of great importance in the present dearth of materials from the Southern hemisphere. Mr. Ellery has most wisely extended his observations of Circumpolar Stars to considerable distances from the pole, and has also observed a large number of stars for comparison with the results of the Northern observatories.

Manuscript Star Charts.

During the past year the Society has become possessed of a very valuable series of MS. Star-charts by presentation from Sir John Herschel.

These charts contain the estimated magnitudes of stars visible to the naked eye in both hemispheres, and were made by Sir

John Herschel both at the Cape of Good Hope and in England. These charts have been strongly bound in volumes. They will be of great value in the case of any suspected changes of magnitude, and especially in the event of a supposed disappearance or outburst of a star.

Spectrum Analysis.

During the past year the most important addition which our science has received from the application of spectrum analysis to the heavens has been obtained at the Paris Observatory. After an extended examination of stellar spectra with the large silvered glass reflector belonging to that Observatory, MM. Wolf and Rayet at length discovered three stars, at no great angular distance from each other, which are distinguished by *bright* lines in their spectra.

These stars are, in Argelander's Catalogue (1850):—

Zone	$+35^{\circ}$	8·5 mag.	R.A. $20^{h}\ 4^{m}\ 49^{s}\cdot3$	$\delta\ +35^{\circ}\ 45'\cdot1$
,,	+35	8 ,,	,, 20 6 27·3	δ +35 46·1
,,	+36	8 ,,	,, 20 9 6·7	δ +36 13·3

In the spectrum of the second of these stars, MM. Wolf and Rayet have observed four bright lines. The brightest of these lines occurs between F and G. The remaining three lines are seen in the part of the spectrum from F to D.

It may be well to suggest that these stars should be carefully watched for variability, as the presence of bright lines may possibly indicate physical conditions existing in these distant bodies, which are possibly of a less permanent character than are those of the stars which possess dark lines of absorption only in their spectra. It is satisfactory to know that Mr. Baxendell has made careful comparisons of these three stars with neighbouring stars, so that if any change of brightness should take place in any of them, it will be readily detected.

Comet II. 1867, has been examined by Mr. Huggins, who concludes, from a somewhat imperfect observation of this faint object, that this small Comet was, at the time of examination, similar in physical constitution to Comet I. 1866.

Mr. Huggins has communicated to the Society, in the *Notices* for March, the results of a further examination of the spectrum of *Mars*. In this paper he gives a more detailed account of the lines which show the existence of an atmosphere similar to that of the Earth, though probably not identical with it. Further, he states reasons for attributing the distinctive ruddy colour of this planet not to the absorptive properties of its atmosphere, but to some peculiarity of certain parts of its surface.

Father Secchi has collected in one memoir all the spectrum observations made at the Roman Observatory. The results of these observations have already been published from time to time in the *Comptes Rendus* and elsewhere. This memoir is printed in the *Volumi dell' Academia dei XL.*

The Great Nebula in Orion.

The discovery of the gaseous constitution of many of the Nebulæ, at the same time that it added to the mystery connected with these objects, gave us fresh hope of acquiring ultimately some knowledge of the relation which they hold to the other objects in the heavens. Changes in their appearance, sufficiently marked to be seen by us, and occurring within periods not so prolonged as to make us despair of being witnesses of them, were suggested to us as highly probable. In the northern hemisphere no nebula presents to an observer so large an amount of detailed structure as the Great Nebula in *Orion.* It will therefore be a source of much satisfaction to Astronomers that the results of the study of this object for many years by the late Lord Rosse are now made public by our fellow, the present Earl of Rosse. A large and exceedingly valuable map of the nebula accompanies his paper, which is printed in the *Philosophical Transactions of the Royal Society.*

The materials at our disposal for the study of this wonderful object have been further increased by the appearance of the valuable and laborious observations of the Great Nebula, and the measures of numerous stars scattered throughout it, which were left unpublished by the late Professor G. Bond. These researches have been carefully edited by Professor Safford, and they form volume V. of the *Annals of the Observatory of Harvard College.* The observations are accompanied by a very beautiful revised engraving of the Great Nebula from the drawings of Professor G. Bond.

D'Arrest's Catalogue of Nebulæ.

Our science has been enriched during the past year by the appearance at Copenhagen of an extensive Catalogue of the Nebulæ observed by Dr. D'Arrest, with the 11-inch refractor of the Observatory of that city, during the years from 1861 to 1867. The Catalogue contains 4800 separate observations of 1942 Nebulæ. Amongst the Nebulæ recorded there are about 390 which have been observed for the first time, or have not had their places determined previously with the accuracy necessary for their recognition. The value of this Catalogue is very greatly increased by numerous descriptions of the appearance of the objects observed, and micrometrical measures of such of them as admitted of this determination.

The Melbourne Reflector.

It will be source of much gratification to all who take an interest in our noble science that the present year will probably witness the erection at Melbourne, Australia, of a powerful telescope in some degree adequate to the exploration of the rich but hitherto very partially-explored regions of the southern heavens. The 4-foot reflector, now in Mr. Grubb's workshop, approaches completion, and according to Dr. Robinson's report, appears to be very successful in respect alike to its optical qualities and to the scarcely less important mechanical arrangements by means of which the observer may, without inconvenience or fatigue, direct and manipulate at his pleasure this magnificent instrument. The telescope is of the Cassegrain form of construction, and is mounted equatorially.

Dr. Robinson says, "The peculiar nature of the mounting brings the circles completely within reach of the observer's assistant; and the mechanical appliances for the motions in right ascension and polar distance are so perfect that we set the instrument on the faint objects which we were examining with great facility and rapidity. One man can reverse the telescope in a minute and a quarter; the quick motion in polar distance is far easier, and the slow one acts more like the tangent-screw of a circle than the mover of such a huge mass. The clock does its work with great precision, the objects remaining steady on the wire as long as I watched them; and there is an ingenious and new contrivance for suiting its speed to planets or the Moon."

The telescope is to be supplied with the necessary apparatus for photography and for spectroscopic investigation.

There still remains the important question as to the most convenient method of sheltering the instrument from rain, and especially from dust. A revolving roof, 46 feet in diameter, is at present suggested as the most expedient method.

Mr. Newall's Great Refractor.

By their successful completion of the bold undertaking to construct an achromatic object-glass, 25 inches in diameter, and 29 feet in focal length, Messrs. Cooke and Sons have done honour to our country, as well as performed a most important service for the science of Astronomy. They state that this magnificent telescope performs admirably, and that the character of the disks of stars seen in it are such as to show that the aberrations of this enormous glass have been properly corrected. The great weight of the two disks of glass forming the object-glass, which amounts to 146 lbs., has required a peculiar arrangement of levers to prevent flexure in the different positions of the telescope.

The equatorial mounting of the telescope is finished, and the expectation may be entertained, that, during the present year, it will reach Madeira, where it is to be placed under the care of Mr. Marth, who is already familiar with the use of large telescopes by the experience which he gained during his sojourn with Mr. Lassell at Malta.

A 7-inch transit-circle will complete this important astronomical establishment, which we shall owe to the munificence of our Fellow, Mr. Newall.

November Meteors.

The meteor shower of November 1867 was not well seen in Europe. The position of the radiant point was not favourable, and the sky was generally clouded. Enough, however, was seen to convince observers that a great display was in progress The observations now coming in from the American Continent show that the shower of last November was but little inferior to that of 1866.

In the *Monthly Notices* for April will be found a discussion by Professor Adams, of the "Orbit of the November Meteors." Professor H. A. Newton, in his Memoirs, contained in Nos. 111 and 112 of the *American Journal of Science and Arts*, had discussed with great care the ancient records of November Showers, and shown that their principal features could be explained by supposing the meteoric matter to move in ellipses with periods of 180·0 days; 185·4 days; 354·6 days; 376·6 days, or 33·25 years. Professor Newton also determined the motion of the node of the orbit, to be about 29′ in 33·25 years. He suggested the possibility of determining which of the five periods, possible so far as the other facts were concerned, was the real period, by determining the disturbing action of the planets upon the orbit of the meteors. In this state the question was taken up by our Fellow, Professor Adams. He first determined the secular motion of the node, on the assumption that the period was 354·6 days, the period which Professor Newton considered the most probable. The motion of the node thus produced would have amounted only to 12′ in 33·25 years. The period of the meteoric matter could not, therefore, be 354·6 days. The periods 180·0, 185·4, and 376·6, proposed by Mr. Newton, would have given results less, or nearly equal to, that resulting from the period 354·6 days. Professor Adams, therefore, finally confined his attention to the period 33·25 years. With this period and a new determination of the other elements of the orbit, made from the observations of November, 1866, Professor Adams found the secular motion of the node in 33·25 years to be 28′; of which 20′ was due to the action of *Jupiter;* 7′ to the action of *Saturn;* and 1′ to the action of *Uranus.* The effects of the disturbing actions of the other planets were small. The close agreement of the theoretical value thus obtained by Professor Adams, with the observed value 29′,

is undoubtedly sufficient to prove that the period of the November meteors is 33·25 years. This result of Professor Adams' investigation is probably the most important contribution Physical Astronomy made during the year.

The very close agreement pointed out by Signor Schiaparelli, between the orbits of the August Meteors and Comet II. 1862, and his bold speculation as to the identity of cometic and meteoric matter has been followed up by the reference of Comet I. 1866, to the November stream. The agreement of the elements of the orbit of Comet I. 1866, and the November meteors appears to have been first pointed out by Mr. C. F. W. Peters.

Parallax of 34 *Groombridge.*

The few stars, the parallax of which has been determined with more or less accuracy, were first pointed out as favourable objects for such an investigation by the extraordinary observed amount of their proper motion. 61 *Cygni* is remarkable for an annual progressive displacement amongst its apparent neighbours by a motion exceeding 5″ per annum. The valuable star-catalogues of the Bonn Observatory show that a similar proper motion of large amount distinguish some other small and inconspicuous stars. In the northern heavens after the five stars — 1830 *Groombridge*, 61 *Cygni*, *Lal.* 21185, *Lal.* 21258, and μ *Cassiopeiæ* — comes the star 34 *Groombridge*, 8.9 magnitude, which Krüger has shown to have an independent motion of 2″·84 yearly. The probable relative nearness to our system which this larger proper motion appeared to indicate induced Dr. Auwers to undertake the examination of the star for parallax. The method adopted by him was the chronographic registration of its Right Ascension in comparison with two neighbouring stars, one preceding it and one following it.

The observations on 79 nights extend during three years, and were made with the 6-foot Equatorial of the Observatory of Gotha. During the registration by the chronographic method the times of passage of 34 *Groombridge* and the two stars of reference across the 15 threads of the eye-piece, the telescope always remained unmoved in Right Ascension.

This carefully conducted investigation leads to a value of the parallax for the star, of the truth of which Dr. Auwers considers there cannot well be any doubt entertained.

If the stars of reference, which are 7 mag. and 8 mag. respectively, be supposed to have a mean parallax of 0″·015, with a mean error of ± 0″·009, the absolute parallax of 34 *Groombridge* will be

0″·307, mean error ± 0″·0376, probable error 0″·0254.

This value will place the star under investigation at a distance from us = 672,000 radii of the Earth's orbit, with a probable

error of 56,000 radii. The light emitted by the star would require 10·6 years to reach the Earth.

There is another star of the 10·5 magnitude within 40″, which appears to be in physical connection with 34 *Groombridge*.

The probable relative nearness of this faint star, as shown by the investigation of Dr. Auwers, gives additional weight to the arguments which have been stated against the assumption that the apparent brightness of the stars may be received as an indication of their distance from our system.

Asteroids and Comets.

Four Asteroids have been discovered during the past year, viz.: ⑫ *Undina*, by Dr. C. H. F. Peters, at Hamilton College, U. S., on 1867, July 7; ⑬ and ⑭, by J. C. Watson, at Ann Arbor Observatory, U. S., on 1867, Aug. 24 and Sept. 6, respectively; and ⑮ *Arethusa*, by Dr. Luther, at Bilk, on Nov. 23.

Three Comets have been discovered during the past year.

Comet I. 1867, by Stéphan, at Marseilles, on January 22. The discovery of this Comet was mentioned in the last Report.

Comet II. 1867, by Tempel, at Marseilles, on April 3.

Comet III. 1867, by Bäker, a clockmaker, of Nauen, on the evening of Sept. 26, and four hours afterwards by Dr. Winnecke.

Our Fellows will, we are sure, receive with great satisfaction this proof of Dr. Winnecke's restoration to health, and return to the scene of his former labours.

Mean Distance of the Sun from the Earth.

In the *Monthly Notices* for May, 1867, will be found a short abstract of a paper by Mr. Stone, containing a numerical determination of the parallactic inequality in the Moon's motion, and a deduction of the corresponding value of the Solar Parallax. The coefficient of the parallactic inequality is found to be 125″·36 and the value of the solar parallax, 8″·85. A paper on this subject by Mr. Newcomb forms Appendix II. to the *Washington Observations* for 1865, published in 1867. This paper contains a careful re-discussion of the observations of *Mars* made near the Opposition of 1862, at the Observatories of Albany, Greenwich, Pulkova, Washington, Cape of Good Hope, Santiago, and Williamstown. The value of the solar parallax deduced by Mr. Newcomb is 8″·855. This value is smaller than 8″·964, deduced by Dr. Winnecke from a comparison of the Pulkova and Cape Observatories, and also smaller than 8″·943, the value found by Mr. Stone from a discussion of the Greenwich observations and corresponding observations at the Cape of Good Hope and Williamstown. There is unfortunately some objection to the use of the Santiago observations in an entire ignorance of the inclination of

the wire. It may be mentioned that the Santiago observations had previously been compared by Mr. Ferguson with twelve corresponding Washington and fifteen corresponding Albany observations of *Mars*. The results thus found for the solar parallax were respectively 8″·834 and 8″·611.

Binary Star Σ 3062.

The orbit of this close and interesting binary star has been calculated with much apparent care by M. Fuss. Since this star was discovered by Sir Wm. Herschel in 1782, it has performed more than three-fourths of a revolution. Its closest approximation took place about 1835, when it was 0″·4±. The results of M. Fuss's calculations give the following elements of its apparent orbit :—

Semi-major axis	1″·287
Semi-minor axis	0·999
Distance of principal star from centre of ellipse ..	0·416
Position-angle of the line joining both points ..	−36° 48′
Position-angle of line of apsides	+46 18

Rotation-Period of Mars.

By means of a careful comparison of the views of *Mars*, by different observers from Hooke in 1666 to Mr. Browning in 1867, Mr. Proctor concludes that

$$88642^{s}\cdot735 \quad \text{or} \quad 24^{h}\ 37^{m}\ 22^{s}\cdot735$$

may be accepted as very nearly the true value of the rotation-period of that planet.

Comet III. 1860.

The numerous exact observations which were made of this Comet in the summer of 1860, appeared to Dr. Auwers to furnish materials for a determination of its path more accurately than is usually possible in the case of these remarkable bodies.

The observations of the Comet at many Northern observatories, from June 18th to July 24th, were followed by observations made in the Southern Hemisphere, from July 8th to Oct. 18th, when it was seen for the last time at the Cape of Good Hope. During the four months of its visibility it had passed through an arc of 96°, as seen from the Sun. The whole of the curve, however, belonged to the same side of its path, as it had already passed its perihelion at the time of its discovery. Dr. Auwers was aided in his research by M. Sievers, who made a new determination of the places of 110 of the stars of comparison.

Dr. Auwers gives several determinations which differ but

very slightly from each other. He appears to consider as most trustworthy those in which the more homogeneous materials only are employed. The following elements are those which result from his fourth determination :—

$$\begin{aligned} T &= \text{June } 16{\cdot}061003 \text{ Gr.} \\ \log q &= 9{\cdot}4666978 \\ \varpi &= 161^\circ\ 32'\ 27''{\cdot}68 \\ \Omega &= 84\ 40\ 32{\cdot}08 \\ i &= 79\ 19\ 25{\cdot}47 \end{aligned}$$

Motion Direct.

Communications to the Society from February 1867 *to February* 1868.

1867.

Mar. 8. On the Planet *Mars*. Mr. Joynson.

On the compatibility of the retrograde motion of the November Meteors with the Nebular Theory. Mr. Hippisley.

On an Astronomical presentiment of Immanuel Kant relative to the constancy of the Earth's Sidereal Rotation on its Axis. Mr. Wackerbarth.

On the measurement of the Apparent Discs of Stars. Mr. Knott.

Notice explanatory of a series of MS. Charts containing the estimated Magnitudes of Stars visible to the Naked Eye in both Hemispheres. Sir J. Herschel.

Observations of a Meteoric Shower at Bishnagur, November 14, 1866. Mr. Masters.

Observations of *Iris* and *Vesta* at Dunsink. Dr. Brünnow.

Observations of the Eclipse of March 5, 1867. Mr. Brothers.

On the estimation of Star Colours. Mr. Kincaid.

On the Spectrum of *Mars*, with remarks on the Colour of the Planet. Mr. Huggins.

Determination of the coefficient of parallactic inequality and a deduction of the Sun's Horizontal Equatorial Parallax from the Greenwich Lunar Observations, 1848–60. Mr. Stone.

Observations of the Solar Eclipse, March 6, 1867. Capt. Noble.

Observations of the Meteoric Shower in Australia. Mr. Duone.

On the disturbance of the Solar Photosphere by Planets. M. Hoek.

A perfect form of Object-glass, deduced from a critical analysis of the Secondary Spectrum. Mr. Dawson.

On the Solar Eclipse of 1868, August. Major Tennant.

Observations of Solar Eclipse, March 5, 1867. Mr. Lassell.

Observations of Solar Eclipse, March 5, 1867. Mr. Prince.

Meteoric Shower of November 1866. Mr. Kincaid.

Meteoric Shower of November 1866, log of ship *Evangeline*. Capt. Wood.

Solar Eclipse, March 6, 1867. Lord Wrottesley.

April 12. Errors in Tables of Logarithms. Mr. Wackerbarth.

Observations of Solar Eclipse, March 5, 1867. Prof. C. P. Smyth.

On the Mass of the Moon, deduced from the Mean Range of Spring and Neap Tides at Dover. Mr. Finlayson.

Errata in his Logarithmic Tables of 1849. Major-Gen. Shortrede.

On the distribution of Nebulæ in Space. Mr. Cleveland Abbe.

Eclipse of the Sun, 1867, March 5, and Occultation of a Star by the Moon, 1867, January 16. The Astronomer Royal.

Errata in two Papers of his. The Astronomer Royal.

Motion of the Solar System in Space. Mr. Stone.

Note on the Calculation of the Sun's Parallax from the Lunar Theory by P. A. Hansen. Mr. Stone.

Determination of a slightly corrected Value of the Solar Parallax, from the data of Le Verrier's Solar Tables. Mr. Stone.

On the Heat attained by the Moon. Mr. Harrison.

Catalogue of New Stars. Mr. Chambers.

May 10. Additional Remarks on the Solar Eclipse of March 5, 1867. Mr. Brothers.

Observations of Comet II. 1867. Mr. Talmage.

Occultation of *Mercury* by the Moon, May 1, 1867. Capt. Noble.

June 14. On the connection between Comets and Meteors. Mr. Stoney.

Meteors observed 13–14 November, 1866. Mr. Burton.

On the earliest traces of good Practical Astronomy. Prof. C. P. Smyth.

On certain appearances of the Telescopic Images of Stars, described by Rev. W. R. Dawes. The Astronomer Royal.

Determination of the Longitude of the Sydney Observatory, from Observations of the Moon and Moon-culminating Stars made in 1859–60. Mr. Stone.

Approximate relative Dimensions of the Asteroids. Mr. Stone.

Observations in India of December Meteors, 1866. Mr. Masters.

Note on the Spectrum of Comet II. 1867. Mr. Huggins.

Occultation of o^2 *Libræ*, May 17, 1867. Mr. Talmage.

On the alleged change of focus requisite in observing Stars widely separated in altitude. Capt. Noble.

Measures of diameters of first bright ring of Star disk. Mr. Knott.

On the importance of Spectroscopical examination of vicinity of the Sun when totally eclipsed. Mr. Brayley.

Recents observations and remarks of Hofrath Schwabe regarding Sun Spots and other Solar Phenomena. Messrs. De La Rue, Stewart, and Loewy.

Note on the Lunar Crater *Linné*. Mr. Huggins.

Nov. 8. On the Transits of *Jupiter's* Satellites and the Lunar Eclipse. Mr. Weston.

Eclipses and Transits of *Jupiter's* Satellites. Mr. Weston.

Jupiter without his Satellites. Mr. Prince.

Note on the Appearance of *Jupiter*, August 21. Mr. Hough.

On the Solar Eclipse, August 1868. Mr. Stoney.

On *Jupiter* without Satellites exterior to his disk. Mr. Burr.

On the Annual Parallax of *Sirius*. Mr. C. Abbe.

On the Lunar Crater *Linné*. Capt. Noble.

Occultations of Stars by Moon, observed at Maresfield. Capt. Noble.

Note on the Lunar Eclipse, September 17, 1867. Capt. Noble.

Jupiter without a visible Satellite. Rev. W. R. Dawes.

Account of an Observing Chair. Rev. W. R. Dawes.

The November Meteors of 1867. Rev. W. Deey.

On the Newton-Pascal Controversy. Prof. Grant.

Determination of the Longitude of the Kingston Observatory. Mr. Williamson.

On some newly-discovered Stars near α *Lyræ*. Mr. Buckingham.

Dec. 13. On the November Meteors, 1867. Mr. E. J. Lowe.

Ditto ditto Mr. Kirkwood.

New Laws of Planetary and Satellitary Motions. Mr. Glennie.

Rotation of *Mars*. Mr. Proctor.

On the Colours of Stars. Mr. Browning.

On the Solar Eclipse of 1868, August 17–18. The Astronomer Royal.

Some remarks on the Value of the Solar Parallax. Mr. Stone.
On Bessel's Mean Refractions. Mr. Stone.
Attempts to facilitate the Prediction of Occultations
1868. and Eclipses. Mr. Penrose.
Jan. 10. *Jupiter* and his Satellites. Mr. Barneby.
Meteoric Shower, Nov. 14, 1867. Lieut. Chimmo.
Ditto ditto. Mr. G.W. H. Maclear.
Ditto ditto, observed at Nassau, Bahamas. Mr. Lawson.
On the Variable Star T *Serpentis*. Mr. Baxendell.
On a contrivance for Reducing the Angular Velocity of Meteors. Mr. Browning.
Inductive Proof of the Moon's Insolation. Mr. Harrison.
A determination of the Moon's Mass. Mr. Stone.
On the Minimum of U *Geminorum*. Mr. Knott.
A new law of the Distances of the Members of the Solar System. Mr. Glennie.
Discovery of a minute Companion to γ *Equulei*. Mr. Knott.

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ADDRESS

Delivered by the President, the Rev. Charles Pritchard, on Presenting the Gold Medal of the Society to M. Leverrier.

The Society's Medal, at all times a subject of deep solicitude to the Council, has this year been awarded to M. Leverrier for his Solar and Planetary Tables. A brief inspection of the earlier pages of the *Nautical Almanac* will be quite sufficient to explain the desire which has long been felt by successive Councils publicly to testify to the distinguished Director of the Imperial Observatory of Paris, their deep sense of the services which he has rendered to astronomical science by the publication of Tables which in this country have superseded all others for the computation of the places of *Mercury, Venus, the Earth,* and *Mars,* in their respective orbits.

Probably few subjects connected with physical inquiries, on a first and distant view of them, present an aspect more unattractive than the contemplation or discussion of long and complicated Planetary Tables. To the mind unprepared, to the eye not specially educated, such Tables must necessarily appear little more than a repulsive mass of symbols, or a maze of numerical expressions strung together, no doubt, after some recondite, but to such a mind, assuredly, unintelligible scheme.

In addressing, however, the members of a learned Society such as ours, it may properly be assumed that the great majority

have reaped the high reward of a diligent prosecution of the noblest of the sciences, and that to their minds, what seems to others a cheerless array of figures, becomes animated with intelligence, and illuminated with the light of thought. The well-instructed geologist, in the fragment of a rock, reads the history of the formation of an ancient continent; from a fossil bone he knows how, by his unerring curious art, to picture to himself the form, and the dimensions, and the habits of a creature whose span of existence, and all its concomitant relations, were allotted to it in ages long since passed away. In like manner the astronomer, in the long columns of the Tables before him, observes not a mere series of abstract numbers, but he traces therein the very pulsations of the planets as they are impelled hither and thither by the approach or recession of the celestial masses forming the system of bodies amidst which they move. He recognises therein the play and the interactions of the chief forces of the Universe. Nor is this all; for ever and anon these apparently lifeless symbols recall to his memory some high achievement of the genius of man; he reads upon the page the imperishable epitaphs of Newton or Bradley, or Lagrange, or Laplace, or Bessel; or he is invited to rejoice in the light of men worthy to be their successors and still spared to ourselves, such as Hansen, or Airy, or Adams, with Leverrier and Delaunay, and a host of others of no inferior fame.

You are aware that a series of modern tables intended to represent the motions of a planet consists, generically, of two parts; the former part representing the place which the planet would have occupied at any specified moment had its motion been calculated for a certain hypothetical but definite ellipse with the Sun in its focus; and the latter part furnishing the amount of deviation caused by the disturbing action of the other celestial bodies. The form, dimensions, and position of the afore-mentioned ellipse, are determined, with the exception of certain secular variations, for the most part by considerations depending on geometry and observation alone; and herein there come largely into play the perfection of the instrument and the skill of the observer. The deviations from this provisional or hypothetical orbit, arising from the perturbations of the other celestial masses, are calculated on the principles of the Newtonian theory as extended by the later investigations of Lagrange and Laplace. These disturbances or deviations from this elliptical motion depend on the masses, distances, and configurations of the planets, or of the elements of their orbits, and are never presumed to be exactly known: they are approximations only, representing more or less the truth of the case, though generally, as we shall see, to a wonderful, and it might be said, unhoped-for degree of precision. It is for very important additions made towards the exactness of these approximations, and for the convenient methods in which they are prepared and arranged for further improvements by future physical astronomers, that we are this day

anxious to express our gratitude to the eminent Director of the Paris Observatory.

When M. Leverrier, in the year 1854, and seven years after the discovery of *Neptune*, was called to the direction of the Imperial Observatory, he found it in a condition of lamentable deficiency, to which we should not here have ventured to allude had not that able astronomer himself pathetically described his disappointment in the Annals of his own publication. Moreover, we shall find in the sequel that this very circumstance soon becomes associated with his fame. He states that, in the imperial city, long adorned by the genius of Laplace, and by the unrivalled analysis of Lagrange, until the year 1800 there was no transit instrument of any description existing within the walls of the Observatory.* It is still more incredible that, up to the year 1828, the instrument then provided was inferior to that with which Bradley had verified his immortal discoveries, and had laid the foundation of modern astronomy some seventy years before. Moreover, at the very time when the great Transit Circle at Greenwich was in full operation, there was not a telescope within the Paris Observatory admitting as much as the fourth part of the light which was then brought to the focus of the noble instrument at the disposal of the English Astronomer Royal, and constructed after the model proposed by himself. English politicians, and even English philosophers, have a peculiar, but well-known tendency to express dissatisfaction at their own national or official arrangements. If among the members of our Society there should chance to be any who are disposed to indulge in this luxury of self-dispraise, I am afraid that our distinguished Medallist has deprived them of, at least, one source of this gratification by his candid statement, that "The Paris Observatory, excepting at the epoch of Dominique Cassini, had always been half a century in arrear of Greenwich, so far as its instrumental resources were concerned."

All this unfortunate deficiency M. Leverrier, immediately upon his appointment, set himself diligently to repair, with the noble ambition of entering, as he says, "upon a pacific contest with other nations, for a place in the foremost rank of astronomical fame, and for the recovery and maintenance of the scientific renown of France."† The present reputation of the Imperial Observatory, and the high and undoubted estimation of its Annals by foreign astronomers, cannot fail to furnish, even to the laudable ambition of its Director, a satisfactory proof that these hopes have been fully realised.

At the time of the establishment of the Paris Observatory in its modern efficiency, M. Leverrier found that, either by mutual arrangement or by prescription, the other great National Observatories had appropriated each to itself a special line of astronomical observation. Greenwich, in obedience to the wise directions of a

* *Annales de l' Observatoire Impériale*, vol. i. † Ib.

Royal Warrant, had become unrivalled for its accurate and persistent observations of the Moon, and of such other phenomena as might contribute to the furtherance and security of the Art of Navigation. Pulkowa, under the direction of the elder Struve, had long gained a well-merited reputation for the advance which had there been made in Sidereal Astronomy. M. Leverrier entered upon his career of a friendly rivalry with these noble institutions by at once assuming for himself the unappropriated but laborious task of recomputing the tabular places of the Planets, on the basis of the analysis of Laplace, with the utmost attainable rigour of exactness, and of then comparing these theoretical places with actual observation. The discordances, however small they might be, between the computed and the observed places, those *residual phenomena*, always so pregnant with the germs of knowledge, would, he hoped, at length lead to the discovery of some hitherto unnoticed action, either of some small interplanetary masses of matter such as meteoric matter, or of cometic matter, or of the matter from whence emanates the zodiacal light; or otherwise might disclose the existence of some intra-Mercurial planet, or of some other forces as yet unsuspected in nature. Such was the aim of this eminent astronomer: an aim worthy of the noblest scientific ambition, but one which would demand the aid of the most subtle resources both of observational and of physical astronomy.

The systematic pursuit of this object required many preparatory and most laborious arrangements. Among others it was imperatively necessary to obtain the best available observations of the Sun and the Planets, commencing from a period as remote as possible from the present epoch. For such a purpose the earliest available materials were the observations of Bradley and of his successors at Greenwich; a few others were to be found in the records of Paris and of Königsberg. With regard to the observations made by Bradley more than a century before M. Leverrier commenced his investigations, it was remarked that his instrumental means and his mode of adjusting his instruments, although the best of his day, were not comparable to those put into modern requisition. The aperture of his transit was exceedingly small, the object-glass was not achromatic, the eye-piece admitted of no sliding arrangement, and the records of the state of the adjustment of the instrument are frequently perplexing and obscure. The object which M. Leverrier had in view was to ascertain the true right ascension and the true time of transit of the Sun and the Planets across the meridian at Greenwich during the century which ended on the 1st of January, 1850. Bessel had already done much towards the reduction of Bradley's observations of 36 'Fundamental Stars,' but M. Leverrier did not consider the results as altogether possessing the rigorous precision required for his present purpose, and he accordingly set himself manfully to the task of completing the reduction of the Right Ascensions of these same 36 Fundamental Stars which had been diligently observed

during the entire century. The completion of such a work, under the direction of a single person, *on a single plan*, and conducted with so much intelligence and care, has conferred a great boon upon astronomers, and forms one of the reasons for which we are this day anxious to express our gratitude.

Again, for the effectual prosecution of M. Leverrier's great design, it was necessary to complete and extend, to a far closer amount of approximation, those formulæ for the Planetary Theory which had been invented or perfected by Laplace. That great geometer, in his immortal work the *Mécanique Céleste*, had indicated those terms only in the expressions for the co-ordinates of a planet which he considered would rise to a sensible amount in a numerical computation. It was on this basis that Carlini calculated his Solar Tables, and that Lindenau executed his for *Mercury*, *Venus*, and *Mars*. These tables of Carlini and Lindenau were long used for the computation of the Solar and Planetary co-ordinates in the *Nautical Almanac* with fairly satisfactory results; but for M. Leverrier's purpose of obtaining the small outstanding residuary differences between observations and the best results of the present theory, they were not deemed sufficiently exact.

For the purposes of improving these Solar and Planetary Tables, M. Leverrier, in the year after his appointment to the Directorship of the Paris Observatory, published in the first volume of the *Annales de l'Observatoire Impériale*, a complete reinvestigation of the whole theory of planetary motion on the basis of the method pursued by Laplace. In particular he expanded the *disturbing function* to a greater extent than it had ever been completely expanded before, leaving it with its numerical coefficients computed to the seventh order of small quantities. Thus one most important result of M. Leverrier's labours consists in this, that he has left the general theory in such a state of advanced development, that its practical application henceforth to the case of any particular planet has become greatly simplified and attended with far less labour than had been the case hitherto.

These laborious preliminary calculations having been thus disposed of, and, what is still better, having been published for the advantage of future astronomers, our distinguished Medallist then proceeded to apply them to the construction of Tables for the positions of the Sun, *Mercury*, *Venus*, and *Mars*, carrying the approximations to a greater degree of minuteness than had ever been effected before. These Tables, as we have already stated, have with excellent results superseded those heretofore in use for the computation of the *Nautical Almanac*.

The question will have occurred to those who have listened to the details of the present address — and I greatly wish that it had been possible to present them to you in a more interesting and agreeable form—the question, I say, naturally arises, What is the degree of accordance between the observed places of the Sun and the Planets, and those which have been thus calculated with all this extraordinary care?

In reply to this question I have been favoured by the Astronomer Royal with the following extracts from observations made and recorded at Greenwich. It is necessary to understand that, in order to eliminate mere accidental errors of observation, it is usual to group together several observations extending over intervals of time during which the error of the Tables may be supposed to change sensibly by quantities depending on the first power of the time.

It is to such mean errors of groups that the following numbers refer:—

Solar Tables.

Mean errors in longitude.

From Carlini	1861,	+ 2″·36
	1862,	+ 2·67
	1863,	+ 2·98
From Leverrier	1864,	+ 0·01
	1865,	+ 0·29
	1866,	− 0·18

The greatest discordances between "monthly mean errors in longitude," were

From Carlini	1861,	1″·97
	1862,	2·67
	1863,	5·21
From Leverrier	1864,	1·73
	1865,	1·88
	1866,	1·69

The improvement here is marked, but Carlini's Tables represented the observations well, and the discordances 1″·73, 1″·88, 1″·69, are larger than could be wished. It is possible, however, that these discordances may not be principally sole errors of theory, but errors introduced into the arbitrary constants from small systematic errors in observation.

The following are the greatest discordances of the mean errors in geocentric longitude for *Mercury*, *Venus*, and *Mars*:—

Mercury.

From Lindenau	1861	9″·79
	1862	10·20
	1863	17·94
From Leverrier	1864	5·29
	1865	3·30
	1866	2·04

Venus.

From Lindenau	1862	15″·97
	1863	34·67
	1864	19·05
From Leverrier	1865	5·44
	1866	6·44

Mars.

From Lindenau	1862	8″·81
	1864	13·98
From Leverrier	1866	0·31

The observations in 1866 are, however, very few.

From the above comparisons, it appears that M. Leverrier has made a notable and important advance in the accuracy of his Tables beyond those of his predecessors. We may, perhaps, form a general notion of the amount of accuracy obtained by observing that the average of the discordances between the observed and calculated places of these three planets during any month, rarely or never exceeds a small fraction of the apparent diameter of the disk of the planet itself. Whether these minute discordances, trifling as they are, indicate some slight imperfection in the mode of observing, whether they result from some deficiency in the application of the ordinary theory, or whether they arise from the existence of some exceedingly small masses of matter not taken into the account of the various attractions, it seems as yet impossible to decide. Happily something yet remains to test the efforts and exercise the sagacity of future astronomers.

At the commencement of this Address, I observed that, notwithstanding the forbidding aspect of the long array of figures in the Planetary Tables, to the initiated they contain a history, and are fraught with the memories of life: they are, in fact, the embodiment of some of the most remarkable and most difficult achievements of the human intellect. In order to illustrate what I mean, I shall first of all select one or two of those terms from the series representing the longitude of a Planet, and which arise from the discoveries of the eighteenth century; and then conclude the illustration before us with two other terms intimately associated with the labours of the eminent man whose services to Astronomical Science we hope to recognise to-day.

It follows from comparatively simple dynamical considerations — we say comparatively, because in reality the very simplest processes of Physical Astronomy require a considerable mental effort to be thoroughly grasped — it follows, we say, from the theory of gravitation, that the Moon's disturbing force on the Earth is such as to cause, not the Earth itself, but rather the centre of gravity of the Earth and Moon, to describe an ellipse round the

Sun. This disturbing action can be shown, again happily from considerations of less than usual complexity, to cause a displacement of the Sun in longitude, oscillating backwards and forwards along the ecliptic, and going through all its phases, in the course of a month. From the principles of gravitation alone, this displacement, when at its greatest, can be expressed in terms of the ratio of the masses of the Earth and Moon, and the ratio of the distances of the Earth from the Sun and from the Moon. Now means exist for obtaining the ratio of these masses, as well as the distance of the Earth from the Moon. This greatest displacement, therefore, of the Sun in the ecliptic, arising from the disturbing action of the Moon, can thus, from theory, be virtually expressed in terms of the distance of the Earth from the Sun. But M. Leverrier, by a very careful discussion of the Greenwich Observations, obtained the amount of this displacement of the Sun in longitude, to an unusual degree of accuracy, and he showed it to amount to six seconds and a half in space. By equating, therefore, the *theoretical* value of this *Lunar Equation*, as it is called, thus expressed in terms of the Sun's parallax, with the $6''{\cdot}5$ obtained from *observation*, the Sun's parallax itself was obtained by M. Leverrier, probably to a greater degree of accuracy than it had ever been obtained before. The result was to increase the solar parallax from the received value of $8''{\cdot}5776$ to $8''{\cdot}95$, or what amounts to the same thing, the distance of the Earth from the Sun was thus reduced from about 95 millions to about 91 millions of miles.

It is not pretended that there was anything essentially new in this application of the theoretical value of the *Lunar Equation* in the Solar Tables, to the determination of the Sun's parallax; M. Leverrier's merit therein consists mainly in his able and accurate discussion of the Greenwich Observations of the Sun. By a curious coincidence, about the same time that M. Leverrier proposed this important correction of one of the prime elements in the Solar System, M. Foucault, whose lamented decease we are now deploring, obtained a similar result from careful experiments on the velocity of light; and still further confirmation of the accuracy of the whole investigation has accrued, from a careful discussion of recent observations on *Mars* at his opposition. We shall, perhaps, have completed the history of the case if we incidentally mention that the necessity of greatly increasing the value of the solar parallax had already been indicated by Hansen's accurate determination of that term in the Lunar Theory which expresses the *reaction* on the Moon herself, of that same force which we have seen disturbs the longitude of the Earth. We here refer to these things, not on account of any particular novelty in the processes themselves, but rather as an illustration of the historical circumstances, or it may be even the cosmical relations, which are sometimes wrapped up in the apparently uninteresting coefficients of detached terms in the Planetary Tables. Even in their intellectual aspect alone, such considerations are invaluable.

With reference to those terms in the Planetary Tables, which, as I said at the commencement of this Address, recall to us the grand memories of the Astronomers of the eighteenth century, our comments must necessarily be very brief. Herein I can do little more than hint at those analytical expressions which remind us of that acute sagacity, and that unwearied patience which is born from conviction, whereby Bradley disentangled the combined action of the motions of the Earth and of Light, from a labyrinth of discordances in his observations of the stars. And then other terms closely follow, completing the story of Bradley's fame. Those mysterious symbols indicate to the instructed mind how, in the small residual discordances which still remained, the great English Astronomer detected the action of the Sun and the Moon, displacing hither and thither the axis of the Earth's diurnal rotation, after a complicated but intelligible law.

There is also another term at the commencement of the series for the calculation of the longitude of the Earth, which is intimately associated with the records of the genius of the greatest of the French Astronomers. It is a term relating to the varying eccentricity of the terrestrial orbit. Laplace referred it to the action of the planets on the motion of the Earth round the Sun. He showed how, by slow degrees, and within certain definite limits, these celestial masses must cause an alternate approach or recess of the Earth towards or from the Sun. With a sagacity, perhaps, never surpassed in the history of science, Laplace showed how this alteration in the eccentricity of the terrestrial orbit, must be accompanied by a corresponding small alteration in the average length of *a month*. And here, again, the small but *definite* amount of this alteration in the length of the month, in the hands of this great philosopher, was made subservient to the demonstration of the constancy of the length of the terrestrial *day* within the limits of historical time. All this curious history is, in reality, wrapped up in one little symbol in the series which represents the motions of a planet. But there is something more curious still behind. In process of time our own Adams detected an error both in the physical considerations, and in the analysis, of Laplace. The great French astronomer had, in fact, miscalculated the alteration of the average length of the month in the course of centuries; and then by a curious interaction it followed next that the length of the day itself must have been slowly decreasing, at all events since the date of very certain remote eclipses of the Sun. This scientific romance was completed by the recent demonstration by Delaunay, that the rotation of the Earth is truly retarded to a trifling but definite extent by the friction of the tides. When the history of this recent Episode in Astronomy comes to be fully written, it will probably be acknowledged as one of the most remarkable and instructive narratives in the annals of science.*

* See Addendum to this Address.

There is no part of M. Leverrier's investigation of the Solar Tables in which he has displayed greater acumen and completeness than in his discussion of the secular effects of planetary interactions on the eccentricities of their several orbits. This is a branch of Physical Astronomy peculiarly intricate and laborious, and much interest attaches to it, because, independently of its historical relations already explained, it is here especially that Lagrange, in his magnificient handling of the analysis, unconsciously fell back upon the equivalent of that self-same mode of representing planetary motions by cycle on epicycle, and orb rolling on orb, which was so ingeniously adopted by the ancient astronomers.

But it is not merely on account of the interest thus attaching to this portion of Astronomy, in a geometrical or historical point of view, that I select it now for the consideration of our Society, but much more because the investigation has been supposed by some eminent philosophers to be fraught with information relative to the physical condition of our globe in ages long anterior to historic date.

It has latterly been one of the most pleasing tasks of those who have had the responsible honour of occupying this chair, to expatiate on the unexpected closeness of the connection recently discovered between great cosmical phenomena and ordinary terrestrial physics. This wonderful continuity of plan has been exhibited, we know, in the physical constitution of the Sun and of the Stars, and in the identity of the orbits of revolution of meteoric and cometic matter; and here again, in this perhaps the most intricate of planetary interactions, we stumble, as it were, upon an unexpected relation between the forces of the far distant celestial masses, and one of the most remarkable of geological phenomena: a relation, moreover, which possibly affords us some clue to the distance of that ancient epoch when our globe first became fitted for the abode of animated existence.

We have seen that the eccentricity of the approximate ellipse described by the Earth round the Sun is in a state of extremely slow but constant flux. This effect is brought about not by any alternations in the configurations of the planets, but by a corresponding flux and reflux in the *forms and positions of the orbits* themselves, even *Neptune* contributing a share which is within the limits of calculation. At the present time the Earth is about three millions of miles nearer to the Sun in our northerly winter that in our summer; our coldest month is about 60° Fh. colder than our hottest, and our winter lasts for about eight days longer than our summer. M. Leverrier has calculated* that 200,000 years ago, the Earth approached the Sun by upwards of ten millions of miles nearer in winter than in summer; the winters were then nearly a month longer than the summers, and in the latitude of London there was a difference of about 112° Fh. between the hottest and the coldest periods of the

* *Annales de l'Observatoire*, vol. ii. addition iii. page [29].

year. Eight hundred and fifty thousand years ago these differences, both of distances and of temperatures, were still further exaggerated.

The question then arises, Was any one of these great alterations of terrestrial temperature the cause, or among the concurrent causes, producing that *Glacial period* which has left behind it so many unmistakable and interesting phenomena? This question, surrounded by many complications, arising chiefly from possible alterations in the levels and configurations of terrestrial continents, especially in the neighbourhood of the North Pole, has been discussed with great moderation and in a truly philosophical spirit by Sir Charles Lyell, in the recent edition of his *Principles of Geology*.* The entire argument, as set forth by this eminent geologist, is well worth consultation; I shall here merely state that, upon the whole, Sir Charles Lyell considers there arises a probability that the great Glacial Period began to set in nearly *a million* of years ago. The argument, however, proceeds a step further in advance; for, inasmuch as naturalists have observed that "ninety-five in a hundred of the shells of the Glacial Epoch were specifically identical with those now inhabiting the northern hemisphere, we may consider a million of years to represent the twentieth part of a complete revolution in species." Arguing in this way, the conclusion at last is drawn that, speaking after the roughest of approximations, "*two hundred and forty millions of years may be the entire series of years which has elapsed since the beginning of the Cambrian period.*"

It is but right to remark that, notwithstanding the cautious and philosophical tenor of the reasoning employed, the approximation is admitted to be rough in the extreme; the marvel is that, by the force of the genius so bounteously given to man, he should be enabled to penetrate, or hope to penetrate, into depths of such mysterious profundity. It will be gratifying to the Astronomical Society to learn that our Secretary Mr. Stone† was the first person to extend the calculation of M. Leverrier's formulæ to the remote periods in question. Subsequently, Mr. Croll carried the computations even to a greater extent.

Such, then, are some of the historical circumstances and the physical consequences associated with that apparently forbidding and interminable array of figures‡ and symbols which M. Leverrier has arranged with such indomitable patience and consummate skill, for the computations of the eccentricities of the planetary orbits at periods whose remoteness exceeds the limits of our conceptions.

There may be, and probably there are, some minds to whom these investigations convey an ill-defined but painful sense that man is overstepping his proper place in nature, when he attempts

* Edition *Ten*, vol. i. page 293.

† *Phil. Magazine*, June 1865.

‡ As a matter of curiosity, or for the convenience of such of the Society as may not have easy access to the *Annales de l' Observatoire*, I insert M. Leverrier's

to peer into such extreme remoteness of the past or the future. Assuredly it is not very uncommon to hear similar speculations associated with a rebuke on the score of the *pride of intellect*, which they are presumed to imply. In reference to such apprehensions, it may be sufficient to remark that we know not as yet, and we never can know except by making the trial, what may be the extent of the intellectual powers with which it has pleased the Sovereign Father of all to endow His children.* Assuredly man is bound, in all gratitude and loyalty to the Giver, to exercise to the utmost all the precious gifts which are entrusted to his care. It is a high quality, moreover, of these gifts, that they grow brighter by the using. As to pride of intellect, the gifted men who have been permitted to disclose to their fellow-creatures such onward stretching and magnificent views of the works of the Creator, know too well,—I had almost said, know too sadly, how vast is the labour, how perfect is the patience, and how limited is the power, with which such accessions to their knowledge are acquired; and Pride is not ordinarily the offspring of Labour and Patience and conscious Limitation of Ability.

Such, then, is a brief account of some of the labours of M. Leverrier during the twenty-one years which have elapsed since, in association with our own countryman, in the happiest and most memorable of the discoveries of modern times, he gave to the

formulæ for computing the eccentricity of the terrestrial orbit, as influenced by the disturbances of all the planets excepting *Neptune*.

Eccentricity of the Earth's orbit (t) years after Jan. 1, 1850 $= \sqrt{h^2 + l^2}$

where

$$h = 0''{\cdot}000526 \sin(g t + b) + 0''{\cdot}016611 \sin(g_1 t + b_1) + 0''{\cdot}002366 \sin(g_2 t + b_2)$$
$$+ 0''{\cdot}010622 \sin(g_3 t + b_3) - 0''{\cdot}018925 \sin(g_4 t + b_4)$$
$$+ 0''{\cdot}011782 \sin(g_5 t + b_5) - 0''{\cdot}016913 \sin(g_6 t + b_6)$$

and

$l = 0''{\cdot}000526 \cos(g t + b)$ + the terms above, substituting *cosine* everywhere in the place of *sine*.

$g = 2''{\cdot}25842$	$g_1 = 3''{\cdot}71364$	$g_4 = 7''{\cdot}5747$
$b = 126°{\cdot}43'\ 15''$	$g_2 = 22{\cdot}4273$	$g_5 = 17{\cdot}1527$
	$g_3 = 5{\cdot}2989$	$g_6 = 17{\cdot}8633$

$b_1 = 27°\ 21'\ 26''$	$b_4 = 35°\ 38'\ 43''$
$b_2 = 126\ 44\ 4$	$b_5 = -25\ 11\ 33$
$b_3 = 85\ 47\ 45$	$b_6 = -45\ 28\ 59$

It may be worth observing (to the uninitiated) that each of the seven sines or cosines refers to the interaction of the seven bodies in the solar system: the action of *Neptune* is omitted. See *Annales de l'Observatoire*, vol. ii. p. 170.

* I trust I may be here permitted, without infringing the laws of good taste, to state that I have endeavoured to discuss this and kindred questions, in the Hulsean Lectures recently delivered before the University of Cambridge, and previously in two sermons preached before the British Association in 1866 and 1867. These are now published by Deightons, Bell and Co.

world ample proof of the rare genius with which he has been endowed. These successful labours,—and they necessarily form but a small part of the occupations of his busy life,—are, I am sure, more than sufficient to secure your cordial and unanimous ratification of the act of your Council, whereby they desire to testify to M. Leverrier their deep appreciation of the important services which he has rendered to Astronomical Science.

Admiral Manners,—In the name of the Royal Astronomical Society, I beg you to convey this Medal to M. Leverrier, the eminent Director of the Imperial Observatory of France.

We hope that the sight of it from time to time may properly serve to remind him, how intelligent fellow-labourers in another country appreciate the great work which he has already done in the service of the most sublime of the sciences; we trust also that it may assure him of the sympathy which we feel in the important and difficult investigations in which he is engaged.

Let the cheerfulness and the pride with which we make the award, afford to M. Leverrier an additional ground for the conviction, that we Englishmen entertain a profound respect for the great Philosophers of France.

And now, Gentlemen, my agreeable work in the service of our noble Society has, by inexorable law, at length, and to my regret, come to its close. In this chair I have passed, assuredly, many of the most memorable, and not a few among the most pleasant hours of my life. Owing to your habitual kindness and forbearance, I am sure that other Presidents must have felt, on an occasion like the present, just as I feel.

One chief element in the gratification which I thus venture to express has arisen from the continued and increasing prosperity of the Society itself.

During the eight years of my close and official relations to the Astronomical Society, whether as one of your Secretaries or as your President, I have enjoyed the pleasure of seeing the numbers who attend your evening meetings more than doubled; the Society itself has increased by nearly a hundred members, and its funded property has been augmented by more than two thousand pounds. Such has been the necessary consequence of consistent perseverance in a plan originally well devised; happily such is the natural fruit of a Society dwelling together in unity. Accept my hearty thanks, and, by the continued maintenance of good fellowship in its highest sense, realize my prayer, *Esto perpetua.*

Addendum.

On revising the paragraphs in page 118 relative to the action of the tides in retarding the diurnal rotation of the Earth, I am reminded, both by the Astronomer Royal and by Mr. Stone, that a somewhat modified and more guarded statement is required by the facts of the case.

Soon after M. Delaunay published his investigation of the effects of tidal friction on the length of the day,* Mr. Airy entered upon an examination of the question, and at first came to a conclusion not confirmatory of M. Delaunay's result:† on subsequently pushing the approximation a step further, in an Addendum to the same communication in the *Monthly Notices*, the Astronomer Royal says: "I have at length discovered two terms which appear to exercise a real effect on the rotation of the Earth;" and then this important and most interesting memoir concludes as follows: "I am very happy to give my entire assent to the general views of M. Delaunay on the existence of one real cause for the retardation of the Earth's rotation."

Since the publication of these Memoirs by M. Delaunay and Mr. Airy, the whole question has been discussed under a variety of points of view, and various objections have been made to the results supposed to be deduced from the mathematical expressions.

Mr. Stone, for instance, from the very first declined to accept, without reserve, the conclusions deduced by M. Delaunay, mainly on the ground that the hypothesis on which the investigation is founded, presumes that the Moon's action is on a *solid* instead of a *fluid* spheroidal shell surrounding and moving round the Earth.‡

Mr. Airy also observes that his own investigation applies to the motion of water in an *uninterrupted* canal surrounding the Earth, and that the obstacle of a continent, such as that of America, might very seriously modify the final result.

It is, however, due to M. Delaunay to state that he saw himself the extreme difficulty, if not the impossibility, of arriving at any precise quantitative result by means of mathematical calculation alone; he says:§ "The exact calculation of the retardation due to the combined action of the Moon and Sun, would require a knowledge of all the circumstances of the tides *as well along the shores as in mid-ocean.* Such a direct calculation is impossible; the actual retardation can only be found indirectly by means of the lunar acceleration, as determined by observation;

* *Comptes Rendus*, Dec. 1865, and *Monthly Notices*, Jan. 1866.
† *Monthly Notices*, April, 1866, p. 227.
‡ Ib. Jan. 1866. § Ib. Jan. 1866, p. 89.

and this gives a new interest to the comparisons of the lunar tables with the ancient eclipses, in the view of thereby arriving at the true value of the lunar acceleration."

At present, then, the case stands thus,—the Lunar Tables, if calculated on the principles of gravitation alone, as expounded by Messrs. Adams and Delaunay, and as confirmed by other mathematicians, will not exactly represent the Moon's true place at intervals separated by 2000 years, provided the length of the day is assumed to be uniform and unaltered during the whole of the intervening period. There are grounds, however, for at least suspecting that, owing to the effects of tidal action, the diurnal rotation is, and has been, in a state of extremely minute retardation, but the mathematical difficulties of the case, owing greatly to the interposition of terrestrial continents, are so great that no definite quantitative results have hitherto been attainable. The solution of the difficulty is one of those questions which are reserved for the Astronomy of the future.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

Admiral R. H. Manners.

Vice-Presidents:

J. C. Adams, M.A. F.R.S., Lowndean Professor of Astronomy, Cambridge.
G. B. Airy, M.A. F.R.S., Astronomer Royal.
A. Cayley, M.A. F.R.S., Sadlerian Professor of Geometry, Cambridge.
Rev. Charles Pritchard, M.A. F.R.S.

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

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The Lunar Crater Linné.

Captain Noble remarks, in regard to the Editor's note, p. 49, that, while Mr. Huggins' sketch shows a minute black crater surrounded by an ill-defined nebulous mass, his own exhibits a relatively shallow crater casting a perceptible shadow from the W. and S.W. wall, but without exhibiting any trace whatever of the smaller one.

Resolution of Council.

At the Council held Saturday, February 8, it was resolved that a paper cannot in general be read at an Evening Meeting unless the same shall have been deposited at the Society's rooms by noon of the day of Meeting.

For Sale.

A transit instrument and clock. The transit instrument, by Jones, is of $3\frac{3}{4}$-in. aperture and 5-feet focal length and firmly mounted on stone piers. The clock, by Hardy, is a very good one, there being no difference between its summer and winter rates. Apply to Mr. Hough, Wrottesley, Wolverhampton.

Superior Achromatic Refractor, $4\frac{1}{4}$ inches aperture, by Mr. Peter Dollond, 6 feet focal length, with finder and four eye-pieces, mounted on new improved Varley's Stand. Price £30. Apply to Edward Crossley, Halifax.

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Printed by STRANGEWAYS AND WALDEN, Castle Street, Leicester Square, and Published at the Apartments of the Society, March 12, 1868.